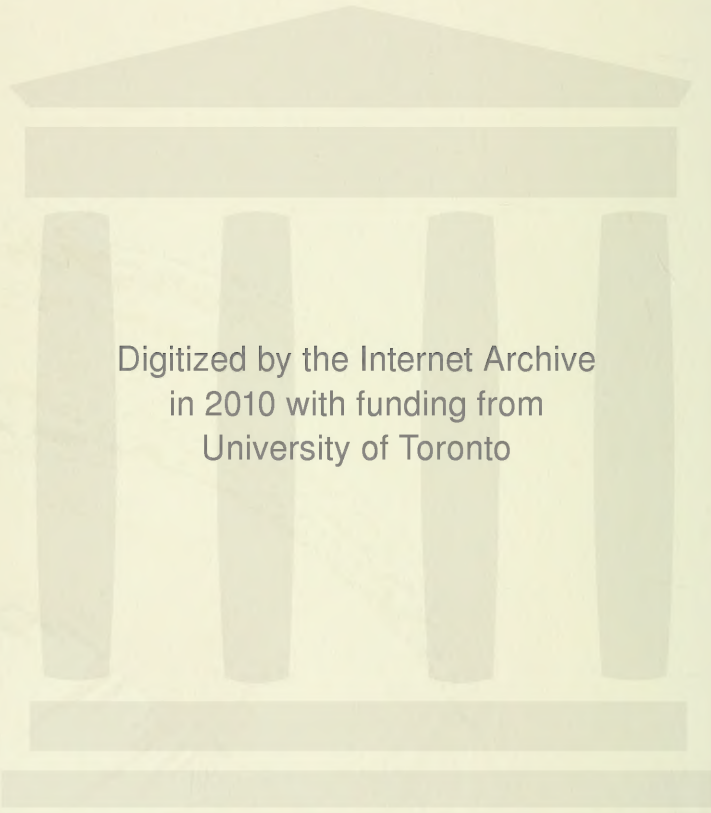


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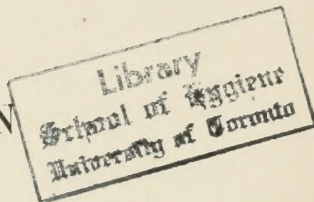
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BULLETIN No. (5) OF THE HYGIENIC LABORATORY,

Treasury Department, U. S. Marine-Hospital Service,

WALTER WYMAN, Surgeon-General.

AN INVESTIGATION



OF A

PATHOGENIC MICROBE

(*B. typhi murium*—Danz)

APPLIED TO THE

DESTRUCTION OF RATS.

M. J. ROSENAU,

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U. S. MARINE-HOSPITAL SERVICE,

WASHINGTON, D. C.

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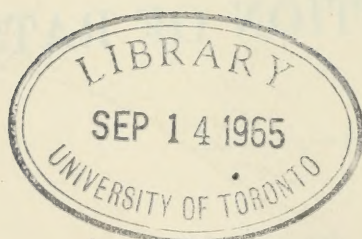
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AN INVESTIGATION OF A PATHOGENIC MICROBE

(*B. typhi murium*—Danyz)

APPLIED TO THE DESTRUCTION OF RATS.

[M. J. Rosenau, Passed Assistant Surgeon and Director of the Hygienic Laboratory,
United States Marine-Hospital Service.]

The subject of the destruction of rats has assumed great importance within recent times on account of the spread of plague to the four quarters of the globe.

In the short time since 1894, when plague broke from its Eastern confines where it had slumbered so many years, a great mass of exact scientific knowledge has been gathered concerning the disease. The relation of the rat to the spread of the disease has especially engaged the attention of investigators.

During the great outbreaks of plague in the middle ages the unusual mortality among the rats was noticed, and it was obvious then that these animals played some rôle in the spread of the disease. We now know definitely that the rat is susceptible to plague. This rodent sickens and dies of the disease in much the same manner as man. An epidemic may be foretold by a great increase of mortality in rats, for when this occurs it may be shown that the rats first contract the disease and afterwards transmit it to man.

The destruction of rats has, therefore, become of the first importance from the standpoint of the public health and the prevention of the spread of plague.

Plague has threatened our country from both its seacoasts, and it is probable that the only reason it has not spread in San Francisco is due to the fact that the disease has not been prevalent among the rats.

In the spring of 1900, J. Danyz described a new method for the destruction of rats by means of cultures of a certain bacillus (*a*). This bacillus he obtained from a spontaneous epidemic among harvest mice and by means of rather complicated and artificial methods he managed to increase its virulence so that it became pathogenic for the several species of rats. The claim is made that the employment of the cultures

a Annales de l'Institut Pasteur, April, 1900. A translation of the article by Danyz appeared in the PUBLIC HEALTH REPORTS of May 25, 1900, Vol. XV, No. 21.

of this bacillus, sold under the name of "Rat Virus," is efficient for the destruction of these rodents.

The following work was undertaken in order to test the validity of this claim.

THE ORIGIN OF THE VIRUS.

In 1889 Loeffler discovered the *bacillus typhi murium*, which he isolated from a spontaneous epidemic among white mice, and which he applied with success to the destruction of harvest mice (*m. arvicola*). Other bacteriologists have observed similar epidemics and have isolated the microbes thereof, morphologically identical with the bacillus of Loeffler, but more or less virulent for the several genera and species of the little rodent.

For example: The *B. typhi murium* of Loeffler was only frankly pathogenic for mice (*m. musculus*) and for harvest mice (*m. arvicola*). A bacillus isolated by Laser was pathogenic for the *m. agrarius*, that isolated by Merechkowski for the *spermophiles*, and finally that isolated by Issatchenko for white rats.

Each of these various bacilli is of such variable virulence that it can not be used practically for the destruction of all species of these rodents.

Danyz, therefore, conceived the notion that it would be of great interest, first to extend the field of action of one of these organisms by increasing its virulence so that it would attack other species of rodents and then, this virulence increased, to maintain it at its highest point. This is how he proceeded to solve this problem.

He first isolated a bacillus from a spontaneous epidemic among harvest mice. This organism was a cocco-bacillus, presenting in general the characteristics of the colon bacillus, and resembling the bacillus of Loeffler—*B. typhi murium*. From the first this bacillus showed a slight pathogenicity for gray rats (*m. decumanus*). Out of 10 animals fed with a culture of this microbe 2 or 3 would die; several others would sicken and recover; others still appeared completely refractory. The fact that a certain number of the rats fed with these cultures always succumbed led to the hope that it would be possible to increase the virulence of this particular microbe by the generally accepted methods—that is to say, by a certain number of passages from rat to rat.

Danyz first tried to increase the virulence of the organism by this means, but he found that successive passages from rat to rat, whether by feeding or by subcutaneous injection, ended by enfeebling rather than increasing the virulence of the microbe. He found that it was rarely possible to go beyond 10 to 12 passages. Sometimes the series was stopped at the fifth passage, or even sooner, by the survival of all the animals undergoing experiment. The result was exactly the same, if, instead of alternating each passage through the animal by a culture

in bouillon or agar, the bodies of animals dead of a preceding passage were fed to others.

It was, therefore, plain that in the evolution of an epidemic caused by this microbe it was necessary to take account of the indisputable diminution of the virulence of the microbe, as well as the natural resistance of the survivors.

Finally, passages of cultures in collodion sacks, inclosed in the peritoneal cavities of rats, were tried, both in interrupted series and by alternating each sack culture with a culture in bouillon or on agar, but the end was invariably a notable diminution of virulence when administered by the digestive tract.

Danyz finally managed to increase the virulence of the organism, so that it was pathogenic for rats, by the following process:

DANYZ'S METHOD FOR INCREASING AND MAINTAINING THE VIRULENCE OF THE VIRUS.

A culture of the bacillus was selected that was fatal for mice in four to five days, and grown in bouillon to accustom it to an anaërobic existence. This was accomplished by growing the culture in flasks as completely filled as possible. The flasks were placed in the incubator until the culture developed, and then kept at ordinary temperature until a deposit formed and the bouillon became perfectly clear. This may take four or five days, and its object is, as above stated, to accustom the microbe to an anaërobic existence.

From the flasks the culture was passed in a collodion sack, which is kept from twenty-four to thirty-six hours in the abdominal cavity of a rat, and then planted anew in ordinary bouillon and thence again into flasks. The culture was transferred from these last flasks to agar, and it is these cultures on agar that Danyz gave to mice to eat, after having diluted them with water and soaked bread and grain in the dilution.

This series of operations was repeated several times, and at the fourth or fifth repetition a decided increase in virulence was noted. Mice, which died only at the end of four to seven days, now died in thirty-six to sixty hours after the ingestion.

After this decided increase in the virulence for mice was obtained, the mice were replaced by white rats, commencing with young rats a month or six weeks old and, as the passages are continued, taking older rats. Proceeding thus and making collodion sack cultures in the abdominal cavity of the species of the animal which it was desired to infect, the culture was specialized, so that it was rendered sufficiently virulent in ten passages. Operating in this manner, Danyz finally succeeded in rendering regularly virulent for gray rats (*m. decumanus*), then for black rats (*m. ratus*), and finally for white rats, a culture which was originally but slightly virulent for the gray rat and entirely innocuous for the other two.

The bouillon used was made from horse meat with 1 per cent peptone, and to which was added a little carbonate of lime to neutralize the acids which are formed during culture and which rapidly diminish the virulence of the microbe.

After this long and painstaking procedure, Danyz obtained a very virulent culture that, contained in flasks and kept from the influence of light and air, preserved its virulence for several months. Planted on agar it preserved its virulence without appreciable diminution for two months. In bouillon, in flasks or tubes stoppered with cotton, it altered very rapidly.

One can not read the foregoing account without admiration for the patience and perseverance required to increase the virulence of an organism by so many passages through the peritoneal cavities of rats by means of the collodion sack method.

DESCRIPTION OF THE ORGANISM.

The cultures with which I did the following work were obtained from the Pasteur Institute.

The organism is a cocco-bacillus, showing distinct motility. Stains well by the ordinary stains and does not stain by Gram's method.

It grows well at ordinary room temperature; also in the incubator, and on all the ordinary media. In bouillon it produces a uniform cloudiness in twenty-four hours. A slight scum forms after several days' growth, which falls to the bottom when shaken. In Dunham's solution it grows well, but produces no indol in twenty-four hours' growth.

It turns blue litmus milk red, but does not cause coagulation.

It grows the whole length of the stab in gelatin, forming small whitish colonies in the deeper portions of the tube. It does not grow over the entire surface of the gelatin tubes. Does not liquify.

It grows under anaërobic conditions.

It ferments glucose bouillon, but not lactose bouillon.

In glucose bouillon it produces $1-\text{CO}_2$, $5-\text{H}$.

It also produces H_2S .

From a general biological standpoint it is plain that this bacillus belongs to the para colon group, and is very similar to the bacillus of rabbit septicæmia, hog cholera, and icteroides—as far as its morphological and cultural characteristics are concerned.

VIRULENCE OF THE VIRUS FOR RATS.

One hundred and fifteen rats were fed with the cultures in various ways during the course of my experiments with the virus. Of these, 46 died—less than half.

Most of the rats used were the gray rat (*m. decumanus*) and the tame white rat. A few (8) of the wild brown, or Norway rat, were used.

The virus is in reality pathogenic for these three kinds of rats when ingested. No special difference was noted in its effects upon the various species.

As the work progressed it soon became evident to me that the result depended largely upon the amount of the culture ingested. By starving rats for a day or two and then giving them all they could be induced to eat and drink of the cultures, a very positive result was obtained. In one instance of 27 rats so fed, all died within a week. If the rats are given a small amount the effect is uncertain—only a few die. In one instance I fed 70 rats with 4 agar tubes, and only 7 died. Upon refeeding them with very large quantities, 9 more died. The survivors were then fed with all they could be induced to eat every day for a week, without effect.

It, therefore, seems plain that a large primary dose proves fatal, and a small dose is not only uncertain, but produces an immunity. This is a very important factor, for it is likely that in the wild state rats would often partake of an amount too small to cause death. Such rats may then subsequently eat large amounts of the culture with impunity.

It would seem, then, that after all, the virus is not so different from the laying out of a chemical poison, depending as it does for its effect upon the amount ingested. A chemical poison, however, does not possess the disadvantage of producing an immunity. Another disadvantage possessed by the virus is the rapid deterioration in virulence which occurs when it is exposed to the action of air and light, or when it becomes dry, as is very apt to happen when laid out for rats in the wild state.

Against this the virus has the very decided advantage over the usual chemical agents used to kill rats that in so far as known it is harmless for man and domestic animals.

THE DISEASE PRODUCED BY THE VIRUS HAS FEEBLE POWERS OF PROPAGATING ITSELF AMONG RATS.

Danyz has pointed out the fact that the epidemic produced by his virus in rats is self limiting. This is due to two causes:

1. The attenuation of the virus.
2. The resistance of the rats.

That the disease can be spread from rat to rat by eating each other can not be doubted, but this method of the spread of the infection is very feeble. I fed rats upon the organs (spleen, liver, etc.), of other rats dead of the infection, without producing any effect. Rats will sometimes eat each other, but sometimes they refuse. I fed dead and sick rats to 10 healthy rats in a cage, and although food was withheld for four days they refused to touch the dead bodies. On other occasions the rats were very vicious, fighting and killing the sick and feeble and eating the dead bodies.

As will be seen from the details of the work which follow, I failed to propagate the disease from rat to rat.

This feeble power of the infection to spread from rat to rat is a decided limitation to the virus as far as its practical application is concerned. It is easy enough to make the rats in a cage eat the cultures soaked in food, but in a wild state this would not be so easy, and if only the rats that eat the virus die, there is little advantage over phosphorous, arsenic, and other chemical poisons.

It is not considered necessary to give in full detail all the experiments made with the virus. A few of the more striking ones follow.

NO. 1. SEVENTY RATS FED ON CULTURES IN INCREASING AMOUNTS.

Seventy white and gray rats were fed April 8 with 4 agar slants (original) of Danyz's virus No. 2, obtained direct from the Pasteur Institute. The cultures were shaken up with water and soaked on dry bread, according to the instructions. The agar itself was also fed to the rats. They ate it all up greedily, food having been withheld for a day previously—

	Died.
Twelve days after feeding.....	1
Fourteen days after feeding.....	2
Thirty days after feeding.....	1
Thirty-one days after feeding.....	1
Thirty-two days after feeding.....	1
Thirty-three days after feeding	1
Total.....	7

Seven of the 70 rats died. One of the 7 died of a peritonitis, due to a long nonmotile bacillus which had no resemblance to the organism that was fed to the rats. The others died of a disease evidently due to the ingestion of the cultures.

In most of the animals the small intestines were found to be the seat of inflammation with enlargement of the lymphatic glands. The spleen and liver showed little change. The lungs were often the seat of congestion and hemorrhagic inflammation—sometimes infarct. The ingestion of the virus causes a local reaction in the intestines, followed by an invasion of the organism into the blood, producing a septicæmia.

The surviving rats, remaining perfectly well to all appearances, were again fed with a fresh culture of the virus. They were now divided into 4 lots and fed with variable amounts in order to determine whether the small quantity ingested produced an immunity and whether the effect is proportionate to the amount eaten.

THIRTY-THREE RATS REFED WITH LARGE QUANTITIES OF BOUILLON CULTURES.

On May 16, after two days' starving, 33 of the surviving rats of experiment No. 1 were given a liter of a young bouillon culture. One-half of this was given as drink, the other half soaked on dry bread. The rats

ate and drank most of it greedily. On May 17 and May 18 this was repeated. No other food was allowed; so that in all the 33 rats ingested almost 3 liters of the virus in three days.

	Died.
May 20, four days after feeding.....	4
May 21, five days after feeding.....	4
May 22, six days after feeding.....	1
Total.....	9

Nine of the 33 rats died. Death came rather suddenly. The others remained apparently healthy. An increased desire to drink probably indicated a feverish condition in some of them. Ordinarily rats die rather slowly from the effects of this virus. They have fever, show symptoms of distress, they are weak and prostrated, and refuse food for a day or two before death.

It, therefore, seems plain that the ingestion of a small amount of the virus killed a few of the susceptible rats—7 out of 70, and left the survivors with a considerable protection, for, after feeding them for three days with overpowering doses, only 9 died out of 33.

TEN RATS REFED ON 10 c. c. OF BOUILLON CULTURE.

Ten of the rats that resisted experiment No. 1 were separated in a cage and subsequently fed with 10 c. c. of a young bouillon culture soaked on bread. This produced no effect.

TEN RATS REFED ON 2 AGAR SLANTS.

Ten of the rats that resisted experiment No. 1 were subsequently fed with 2 agar slants, shaken in water and soaked on bread in accordance with instructions of Danyz. This produced no effect.

TEN RATS GIVEN DEAD RATS TO EAT.

Ten of the rats that resisted experiment No. 1 were placed in a separate cage and deprived of all food for four days, during which time rats sick and dead of the infection were placed in the same cage. They refused to touch the dead bodies. None of the 10 rats took the disease.

It is evident from the foregoing experiments that small primary doses are uncertain in their effects.

Another test was made, using large overpowering doses from the start.

NO. 2. TWENTY-SEVEN RATS FED ON VERY LARGE QUANTITIES OF CULTURE.

Twenty-seven white and gray rats were deprived of food for twenty-four hours and then given (April 11) a liter of a young bouillon culture of the virus soaked on bread. In addition they were given another

liter of the culture as drink, and 6 agar slants. They ate most of the bread during the night, and drank a considerable quantity of the liquid. Two days following (April 13) they were given another liter of a young culture soaked on bread. On this day the rats seemed sick, 1 died. They ate little or none of the bread, but licked up all the liquid. On April 14, the third day, the rats were sick, very thirsty, refused food, 2 were dead. From this on, the rats refused food and succumbed one after another until all were dead—

	Died.
Two days after feeding.....	1
Three days after feeding	2
Four days after feeding.....	10
Five days after feeding.....	7
Six days after feeding.....	7
Total	27

All these 27 rats, then, died within a week after being fed with an overpowering amount of the virus.

The result, therefore, seems to depend on the amount ingested as well as the virulence of the cultures.

RATS AND MICE FED ON TOXINS.

A toxin was made by growing the organism in flasks containing 1 per cent peptone bouillon. The flasks were left over night in the incubator at 37° C., and then the growth continued at room temperature. At the end of two weeks the cultures were killed by exposing the flasks to 70° C. for several hours. The resulting product was fed to mice and rats, and was found to produce a certain toxic effect. It seems very probable that the toxin favors the pathogenic action of the organism. This question, not having a direct practical bearing on this particular subject, will be discussed at another time. It may be stated here, however, that animals fed on the toxin seem to acquire a certain amount of immunity against the virulent cultures.

VARIOUS METHODS OF FEEDING.

Rats were fed upon the organs (livers and spleens) of other rats dead of the infection, and in other ways, without producing any effect.

THE SURVIVORS FED ON LARGE QUANTITIES.

Finally, I had about 60 rats, which had survived the various experiments, on my hands. I fed them all with large amounts of cultures in order to get rid of them. They were given as much of the cultures as they could be induced to eat, every day for a week, without apparent effect. The immunity produced is, therefore, very positive and lasts at least several months.

SUMMARY.

The substance known as Danyz's Virus consists of a culture of a bacillus belonging to the para colon group. It appears to be indentical with the *bacillus typhi murium* of Loeffler.

This organism is naturally pathogenic for mice, in which rodents it sometimes produces spontaneous epizootics. Its virulence has been raised and specialized by artificial means in the laboratory, so that it has become fatal for rats by ingestion. This artificial virulence is not very stable. It may be maintained under special conditions a few months, but the virulence is apt to fall off, especially on exposure to light and air.

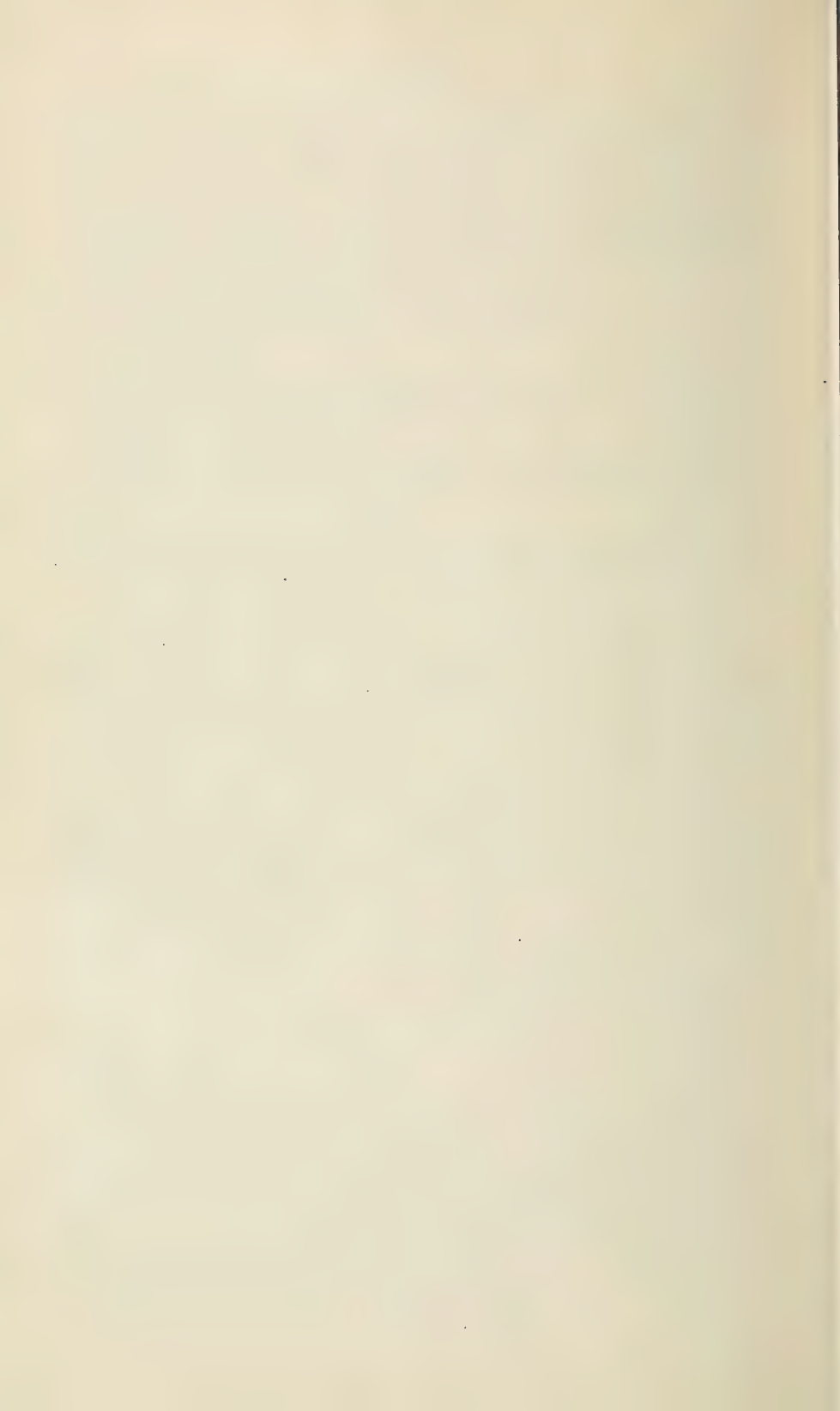
As far as rats are concerned, the effect depends somewhat on the amount ingested. Large amounts are frankly fatal. Small quantities are uncertain. Rats that survive the ingestion of the virus are rendered immune. Such rats may eat large amounts of the virulent virus with impunity.

The infection caused in rats by eating the virus has feeble power of propagating itself from rat to rat. It, therefore, can not produce a widespread epizootic among these rodents. In practical use it must be spread around so that as many of the rats as possible will eat it.

In many respects it resembles a chemical poison, with this great advantage, viz, that it is harmless, in so far as known, to man and domestic animals. It has the great disadvantage, that chemical poisons do not possess, of rendering the animals immune by the ingestion of amounts that are insufficient to kill, or by the ingestion of cultures that have lost a little of their virulence.

In my experiments I succeeded in killing less than half the number (46 out of 115) of rats fed. The conditions in a cage are so much more favorable for the fatal action of the virus than could possibly be the case in nature that it is safe to assert that a less number would succumb in a wild state.

The virus may, therefore, be used as one of the means in the fight against rats, but it is far from being a sure means of exterminating these rodents in a particular place.



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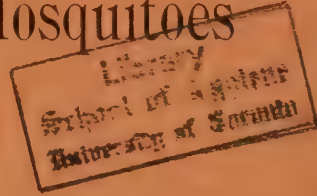
BULLETIN No. 6 OF THE HYGIENIC LABORATORY,

Treasury Department, U. S. Marine-Hospital Service,

WALTER WYMAN, Surgeon-General.

SEPTEMBER, 1901.

Disinfection Against Mosquitoes



WITH

FORMALDEHYD AND SULPHUR DIOXID.

M. J. ROSENAU,

Passed Assistant Surgeon, Director Hygienic Laboratory,

U. S. MARINE-HOSPITAL SERVICE,

WASHINGTON, D. C.



**WASHINGTON:
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DISINFECTION AGAINST MOSQUITOES WITH FORMALDEHYD AND SULPHUR DIOXID.

[By M. J. Rosenau, Passed Assistant Surgeon, Director of the Hygienic Laboratory,
U. S. Marine-Hospital Service.]

Until lately, mosquitoes and flies were looked upon merely as annoyances, but since it has been proved that they are able to transmit the infection of pestilential diseases, we must now regard them as dangerous vermin. When the matter is generally understood, it will be a greater reproach to the housewife to have mosquitoes and flies in the home than bed bugs, and it is the duty of sanitarians to spread an abhorrence for these most common and most dangerous of domestic pests.

The mosquito is known to transmit the infection of malaria and filariasis. The theory of Finlay, so brilliantly proven by Reed and his colleagues (Carroll, Lazear, and Agramonte) of the Army Medical Commission, that the mosquito transmits yellow fever must now be accepted as an established fact. One of the next problems is the destruction of the infected mosquitoes, and we have undertaken the following work to test the insecticidal value of formaldehyd gas and sulphur dioxid in the work of practical disinfection :

METHODS.

In our experiments we have endeavored to imitate the conditions found in actual practice in so far as they were compatible with accurate control of the results.

The mosquitoes used were good specimens of the *Culex pungens* raised in our laboratory. The insects were from one to seven days old and consisted of males and females in about equal proportions. They were exposed in battery jars covered with gauze, or in small pill boxes with gauze lids. The battery jars were used in order to allow the mosquitoes to seek and choose their own protection. To this end, crumpled crash toweling and paper, sometimes dry, sometimes moist, were placed loosely in the jars. It was always found that the insects would hide in the more remote folds and corners, thus often entirely escaping the stronger percentages of the gas.

After this self-protecting instinct was clearly demonstrated, mosquitoes were placed in pill boxes, as with these we were able to expose the insects

ACKNOWLEDGMENT.—I am pleased to acknowledge the assistance rendered by Asst. Surg. S. B. Grubbs, U. S. Marine-Hospital Service, not only in conducting under my direction about half of the experiments, but for valuable suggestions throughout the work.

under definite conditions, and to determine exactly the amount of protection required to prevent the penetration of the gas to the mosquitoes in sufficient strength to kill them.

The pill boxes were small cylindrical cardboard boxes, one-half an inch high by one and one-half inches in diameter. The lid of each box was replaced with gauze mosquito netting.

Mosquitoes thus confined often die within twenty-four hours under favorable conditions of temperature and moisture. Therefore, if one survives in a box containing several insects, the death of the others must not be attributed to the effects of the disinfecting gas. All the mosquitoes in the box must be dead to draw positive conclusions.

Another advantage of these boxes was that we were enabled to compare the germicidal with the insecticidal power of the gases used. Cultures of bacteria were exposed upon slips of paper in similar pill boxes, which were sterilized for this purpose. These boxes containing the cultures were placed alongside the boxes containing the mosquitoes, so that the two were subjected to exactly similar conditions as far as that was possible.

The cultures were exposed upon sterile strips of white filter paper. The spores of the hay bacillus and of anthrax were thoroughly dried in the incubator at 37° C. Rich garden earth was emulsified with water and the strips impregnated with the suspension. These were always dried before being exposed. Fresh young cultures of a staphylococcus, pyocyaneus, and bacillus ieteroides were used to inoculate the slips and were exposed moist and freshly prepared. These were selected as representative of the non-spore-bearing group of microorganisms.

In some of the experiments the bacteria and the mosquitoes were not exposed under precisely similar conditions. In such cases, noted hereafter, the slips of paper impregnated with the cultures were placed in Petri dishes, in envelopes, and in small boxes. The Petri dishes were opened so that the gas could gain free access to the test slips. The envelopes were not sealed. The boxes were small cardboard cylinders about 2 inches long by 1 inch in diameter, with 5 small holes punched in both top and bottom to permit the entrance of the gas.

FORMALDEHYD GAS.

It is a well-known fact that formaldehyd gas readily enters into combination with the protoplasm of the lower forms of vegetable life, which makes it a very efficient germicide. It is, however, not toxic to the higher forms of animal life. It is very irritating in its effect upon the mucous membranes of rats, mice, guinea pigs, rabbits, and mammalian animals generally, but not necessarily fatal, even after prolonged exposures. Many insects, such as roaches and the like, may be exposed to strong concentrations of the gas a long time without apparent effect.

Formaldehyd gas kills mosquitoes whenever the gas comes in direct contact with them in sufficient concentration and for a sufficient length of time. When exposed *directly* to the gas produced by any of the methods commonly used for disinfecting purposes, the mosquitoes die within few minutes. If the insects are confined in a bell jar and some formalin is dropped inside, they soon show signs of agitation and shortly drop down, dead. They may, however, live over night in a very feeble atmosphere of the gas.

The conditions necessary to obtain this direct contact, however, can not always be obtained in actual practice. Rooms are frequently not tight enough to obtain the concentration of the gas required. The mosquitoes can not be held in direct contact with the gas, for their sense of self-preservation helps them to escape. The period of irritation, lasting several minutes even in the bell jar, enables the insects to hide in available places, such as the folds of garments, hangings, or fabrics, or in the cracks and crevices where the gas only reaches in a diluted form. If the room is not thoroughly sealed, some of the mosquitoes will surely get away, for their instinct in finding tiny avenues of escape is remarkable. The escape of one infected mosquito might be the spark that would rekindle an epidemic.

In general, it may be stated that to succeed in killing mosquitoes in a closed space with formaldehyd gas, the following definite requirements are essential. A large volume of the gas must be liberated quickly, so that it may diffuse to all portions of the room in sufficient concentration. The room must not have cracks and chinks where the insects will breathe the fresh air entering, especially if these openings are to windward. The room must not have heavy drapery, clothing, bedding, or other fabrics, so disposed that the insects may hide in the folds, away from the full effects of the gas.

Four methods of evolving formaldehyd gas were used, namely:

1. The sheet method.
2. The Kuhn lamp.
3. The Trenner-Lee formaldehyd disinfector.
4. The autoclave.

THE SHEET METHOD.

This method was applied by hanging sheets in the room and spraying formalin (40 per cent) upon them by means of Dr. Behn's formaldehyd sprinkler. The solution was sprinkled on the sheet in small drops in order to facilitate evaporation and prevent polymerization. For bacterial disinfection, 5 ounces of the solution are prescribed for each 1,000 cubic feet of space, the time of exposure to be not less than five hours.

No. 1.

In a room of 2,000 cubic feet capacity, 4 sheets were hung on cords crossing the room. Twenty ounces (600 c. c.) of formalin (40 per cent)

were sprayed on the sheets and the room was closed. This room has 2 doors and 4 windows, is of wooden construction, and rather leaky. The windows and doors were simply closed and no pasting or calking was done. Time of exposure, six hours.

Mosquitoes.

	Dead.	Alive.
In battery jar one-third full of absorbent cotton and crumpled toweling..	0	12
In pill boxes—		
1. In single fold of a towel.....	0	3
2. In double fold of a towel.....	0	2
3. Rolled loosely in a towel.....	0	3
In large test tubes—		
1. Very thin layer cotton tied over mouth.....	1	0
2. Very thin cotton stopper.....	0	1
3. Ordinary cotton stopper, 1½ inches.....	0	1
4. Large cotton stopper, 2½ inches.....	0	1

In order to compare the effect upon mosquitoes with the germicidal power of the gas, bacteria were exposed at the same time as follows:

	Garden earth.	Subtilis spores.	Anthrax spores.	Staphy- lococcus.	Pyocya- neus.	Icter- oides.
In envelopes, not sealed.....	+	+	—	—	—	—
In Petri dishes.....	+	—	—	—	—	—
In paper boxes, perforated ends.....	+	+	+	—	—	—

NOTE.—Throughout these experiments + means growth, and — no growth.

From this experiment it appears that the formaldehyd was strong enough in the six hours' exposure to kill all the non-spore-bearing organisms and some of the spores, but that it had no effect upon the mosquitoes, protected as they were by various layers of towel or cotton.

As the insects and the bacteria were not exposed under precisely similar conditions, the following experiment was made:

No. 2.

The conditions of this experiment were similar to those of No. 1, excepting the time of exposure was lengthened to twenty hours. The same room of 2,000 cubic feet capacity was used and 20 ounces (600 c.c.) of formalin (40 per cent) were sprayed upon 4 sheets.

This time the mosquitoes and the paper slips impregnated with the cultures of bacteria were exposed under exactly the same conditions. The insects were confined in little pill boxes with the gauze covers described above. The slips of paper impregnated with the cultures were placed in precisely similar boxes, the only difference being that the boxes were sterilized before receiving the slips. One series of boxes contained the mosquitoes, another subtilis spores, and the third pyocya-

neus. These 3 series were exposed side by side under the conditions as noted in the following table:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes:				
In pocket of duck coat hung on wall, pocket toward wall.	3	1	—	—
Same as above, except pocket open and turned out.....	5	0	+	—
Under 2 layers of damp toweling.....	5	7	+	—
Under 2 layers of dry toweling.....	4	0	—	—
In pocket of overalls hung on wall, pocket closed and hung against the wall.....	1	4	+	—
Control; exposed to the gas without protection	4	0	—	—

It is perfectly plain from this experiment that the mosquitoes exposed freely to the action of formaldehyd are killed. They are, however, able to survive an exposure to less concentrated atmospheres of the gas. They lived in the pocket of a coat and overalls, and under a few layers of toweling, despite the fact that the gas penetrated to these places in sufficient strength to kill pyocyanus and sometimes dry subtilis spores, lying right alongside of the insects, and exposed to precisely similar conditions.

The conclusion is evident, therefore, that in rooms where the mosquitoes may have similar places to hide, this method is not available.

THE KUHN LAMP.

This lamp operates upon the principle of dehydrating methyl alcohol into formic aldehyd. The vapor of the alcohol is passed over incandescent platinum in a state of fine division upon perforated asbestos discs. In practical disinfection against bacteria, 20 ounces of wood alcohol are prescribed for each 1,000 cubic feet of air space, the exposure to be not less than six hours.

No. 3.

In the room of 2,000 cubic feet capacity described in experiment No. 1, 40 ounces of wood alcohol were consumed in a Kuhn lamp. The time of exposure was twenty-four hours. Temperature 81° to 87° F. The mosquitoes and the slips containing the cultures were in similar boxes, and exposed side by side to the same conditions, as follows:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes:				
Under 1 layer damp toweling.....	1	2	+	—
Under 2 layers damp toweling.....	1	2	+	—
Under 4 layers damp toweling.....	4	0	+	—
Under 4 layers dry toweling.....	2	1	+	Lost.
Wrapped in dry towel, 4 layers.....	5	0	+	—
Wrapped in damp towel, 4 layers.....	4	0	+	+
In overalls pocket (damp), hung up, pocket toward wall...	0	4	+	—
In overall (dry), hung up, pocket turned out.....	0	4	+	—
In canvas mail sack, mouth tied.....	0	4	+	— ^a
Under pile of loose clothes.....	1	3	+	+
Control, in air-tight jar, dry.....	0	3	+	+
Control, in air-tight jar, with moisture.....	2	1	+	+

^a Contaminated.

The conditions of this test corresponded about to the requirements of bacterial disinfection, the time of exposure being longer than necessary to destroy surface infection.

From this test it is again plainly shown that the formaldehyd gas penetrates in sufficient strength to kill a non-spore-bearing organism (*pyocyaneus*) into pockets of overalls or through 1 layer of toweling, but not in sufficient strength to kill mosquitoes. There seems to be an analogy between these insects and the resistance shown by the spores.

The fact that some of the mosquitoes die when confined in a little pill box for twenty-four hours should not be taken as an indication that they were killed by the gas, for mosquitoes thus confined, even under favorable circumstances of moisture and temperature, often die. It is very common in our controls to find half or more of the insects dead within twenty-four hours; therefore, if 1 mosquito survives the exposure, we consider that the death of the others in the same box was not due to the effects of the gas.

No. 4.

This test was made in a small closet with 1 window, capacity, 250 cubic feet. About 17 ounces (500 c. c.) of wood alcohol were consumed in a Kuhn lamp. This is an excess of nearly 4 times the usual quantity required in disinfection. The room is of fairly tight construction and the door and window were closed without sealing or pasting. The temperature during the exposure was 82° to 86° F. The time of exposure, twenty hours.

The mosquitoes and the bacteria in this test were exposed in the pill boxes to the same conditions, as follows:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyaneus.
In pill boxes:				
Under 2 layers of damp toweling.....	3	2	+	—
Under 2 layers of dry toweling.....	5	0	+	—
In pocket duck coat, hanging on wall, pocket turned to wall.....	6	0	+	—
In pocket duck coat, pocket stands open.....	4	0	—	—
In closed pocket of trousers, hung up.....	4	0	+	—
Controls, exposed without protection.....	3	0	+	—

It is evident that even excessive amounts of the gas, such as were employed in this test, are not sure insecticides if the mosquitoes are not exposed directly to the action of the gas. Note that 2 out of 5 mosquitoes survived under 2 layers of damp toweling. Despite the large amount of wood alcohol oxidized in the lamp, there was not enough formaldehyd gas generated to kill the subtilis spores exposed as controls.

THE TRENNER-LEE FORMALDEHYD DISINFECTOR.

This apparatus depends upon the principle of generating the formaldehyd gas from its watery solution, plus 1 per cent of glycerin, by distillation from a retort without pressure. For the purposes of disinfection against bacteria 12 ounces of formalin (40 per cent) are prescribed for each 1,000 cubic feet of air space.

No. 5.

This experiment was made in the same room, of 2,000 cubic feet capacity, as No. 1, and, as before, no calking or pasting was done. Twenty ounces of formalin (40 per cent), with the addition of 1 per cent of glycerin, were distilled in the Trenner-Lee apparatus. It required about forty five minutes to evaporate this quantity. The room was kept closed six hours.

The cultures of bacteria were exposed as follows :

	Paper slips impregnated with—					
	Garden earth.	Subtilis spores.	Anthrax spores.	Staphylococcus.	Pyocyanus.	Icteroides.
In envelopes, not sealed.....	+	+	+	—	—	—
In Petri dishes, open.....	+	+	—	—	Lost.	—
In paper boxes, perforated ends.....	+	+	+	+	—	—

Mosquitoes were exposed as follows:

	Dead. Alive.	
In a battery jar containing crumpled paper and a crumpled towel, loosely filling about half the jar (the object was to afford a hiding place for the mosquitoes).....	0	12
In pill boxes—		
Covered with 1 layer toweling.....	0	5
Covered with 2 layers toweling.....	0	6
Covered with 4 layers toweling.....	0	4
Under 2 layers moist tissue paper.....	0	5
Wrapped in 4 layers damp toweling.....	0	8
Wrapped in 6 layers damp toweling.....	0	7
Rolled 4 times in a towel, ends not closed.....	2	6
Rolled 10 times in a towel, ends not closed.....	0	4

In this experiment the insects succeeded in hiding in the remote folds of the paper and towel in the battery jar, so that they escaped the effects of the gas, which was in sufficient strength to kill most of the non-spore-bearing organisms. Almost all the insects survived the other conditions of this test. Short exposures (six hours) to the ordinary percentages are, therefore, not enough to kill mosquitoes with as slight a protection as 1 layer of a crash towel.

No. 6.

This experiment was done under the same conditions as the preceding. Six hundred cubic centimeters, or about 20 ounces of formalin, were again used in the Trenner-Lee formaldehyd disinfector. The exposure this time, however, was eighteen hours, and the mosquitoes and cultures were placed under precisely similar conditions, as follows :

	Mosquitoes.		Bacteria.					
	Dead.	Alive.	Garden earth.	Subtilis spores.	Anthrax spores.	Pyocyaneus.	Staphylococcus.	Icteroides.
In battery jar with crumpled towel loosely filling half of it.....	2	1	+	+	+	—	—	—
In pill boxes—								
Under 1 layer of newspaper	2	0	+	—	.....	—	—	—
In corner of newspaper, folded twice.....	2	0	.....	+	.....	—	—	—
Under 2 layers dry toweling....	2	0	+	+	+	—	—	—
Under 4 layers dry toweling ...	1	0	+	+	—	—	+	—
Wrapped tightly in a small towel	2	1	.....	+	.....	—	—	—
In open pocket of coat, hung up.....	2	0	.....	—	+	—	—	—
In open pocket of duck coat, hung up.....	2	0	+	+	—	—	—	—
On the floor under several towels.....	1	1	.....	.....	+	.....	.....	.....

These results are better than No. 5, in which the exposure was only six hours, the other conditions being similar. However, one of the mosquitoes escaped destruction in the battery jar, one tightly wrapped in a towel, and one on the floor under several towels laid loosely in a heap over the boxes containing the insects. These conditions might be found in actual practice, especially in bedrooms containing heaps of clothing, bedding, or other fabrics where the mosquitoes, according to our observations, could readily find a hiding place where they might escape the action of the formaldehyd.

In this test the gas was in sufficient concentration to kill all the non-spore bearing bacteria, excepting a staphylococcus under 4 layers of toweling. Some of the spores were also killed under conditions not requiring deep penetration.

No. 7.

In the third test with the Trenner-Lee formaldehyd disinfector a small room containing 250 cubic feet was used. This room is the same as the one described under No. 4. The single window was simply closed without pasting the cracks. Five ounces of formalin with 1 per cent of glycerin

were distilled. The time of exposure was twenty hours. The mosquitoes and the cultures were exposed in pill boxes under similar conditions, as follows:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes—				
Controls, exposed to the gas without protection.....	5	0	+ <i>a</i>	—
Under 2 layers of dry toweling.....	4	0	— <i>b</i>	—
Wrapped tightly in dry towel, 6 layers.....	7	0	—	—
Under 2 layers of a damp towel.....	6	0	+	—
In pocket, duck coat, hung up, with pocket toward wall...	7	0	+	—
In pocket of overalls, folded once and laid on floor, pocket next to floor.....	4	2	+	—
In trousers pocket, deep, hung up.....	0	4	+	—
In corner of a folded newspaper, under 7 layers.....	2	6	+	—
On floor under towels, heaped in a pile.....	2	4	+	—
In canvas mail sack, mouth closed.....	3	3	+	—
In bottom of a battery jar, under 2 layers toweling.....	6	0	+	—
<i>a</i> Delayed.		<i>b</i> Contaminated.		

The insects survived the twenty hours exposure in the pockets of overalls and trousers, under 7 layers of newspapers, under a heap of towels, and in a canvas mail bag. The insects under less severe conditions were all killed. The gas had practically no effect upon the dried spores, although it penetrated in sufficient quantity to kill all the pyocyanus, despite the fact that some of the conditions required deeper penetration than is ordinarily the case in practical disinfection.

THE AUTOCLAVE.

The autoclave evolves the formaldehyd gas by heating formalin, mixed with a neutral salt, in a retort under a pressure of at least 45 pounds to the square inch.

The ordinary requirement with this form of apparatus in disinfecting against bacteria is to use 10 ounces of the formalin solution for each 1,000 cubic feet of air space with an exposure varying from two to twenty-four hours. The United States Quarantine Regulations require a twelve hours exposure and 400 c. c., or about 13 ounces per 1,000 cubic feet of space.

It is true that in this process not all the solution put in the retort is evaporated, and the amount remaining is noted under each experiment. However, there is very little formaldehyd in the residue, for in an apparatus evolving gas under pressure, especially if a neutral salt glycerin has been added to raise the boiling point, practically all the gas passes off with the first half of the liquid.

No. 8.

This experiment was done in the room of 2,000 cubic feet previously described. (See No. 1.) Twenty ounces (600 c. c.) of glyco-chloro-

formol was used. This is a mixture of formalin with 20 per cent of calcium chlorid and 10 per cent of glycerin. About 4 ounces of the solution remained in the retort after the operation. The time of exposure was twelve hours, making the conditions correspond about to the requirements as laid down in the United States Quarantine Regulations. The temperature of the room during this experiment was 72° to 87° F.

The mosquitoes and the cultures were exposed in the pill boxes, placed side by side, so that the conditions were as nearly alike as possible.

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes—				
Under 1 layer damp towel.....	2	2	+	—
Under 2 layers damp towel.....	3	1	+	—
Under 4 layers damp towel.....	0	2	+	—
Under 4 layers dry towel.....	2	5	+	—
Wrapped in 4 layers dry towel.....	0	1	+	—
Wrapped in 4 layers damp towel.....	0	3	+	—
In damp pocket of overalls, hung up.....	0	4	+	—
In dry pocket of overalls, hung up.....	10	5	+	—
In mail bag, mouth tied.....	0	8	+	— ^a
Under pile of towels, loosely heaped.....	1	4	+	—
On wall behind a duck coat.....	3	3	Lost.	—
Control, in air-tight jar, with moisture.....	2	2	+	+

^a Contaminated.

From this test it is plain that the requirements of the United States Quarantine Regulations, which are sufficient to destroy non-spore-bearing bacteria in the pockets of clothing or under 4 layers of towels, are impotent to destroy mosquitoes similarly protected. Some of the insects survived in each one of the boxes. Even in the control box 2 of them were dead. It is, therefore, plain that the occasional deaths in all the other cases can not be attributed to the effects of the gas.

The analogy between the resistance of the spores and the resistance of the mosquitoes is strikingly shown in this test.

No. 9.

The second experiment with the autoclave was done in the same room as the above, but under different conditions. The exposure was short and the percentage of formaldehyd very high. Two thousand cubic centimeters, or about 65 ounces, of the glyco-chloro-formol solution was used. This is 3 times the amount required for ordinary disinfection. After a pressure of 60 pounds to the square inch was obtained, the gas was allowed to enter the room. The operation was continued at this pressure for fifteen minutes. One-half of the liquid remained in the autoclave at the close of the operation.

The total time of exposure was two hours and fifteen minutes, counted from the time the gas was first allowed to enter the room. The temperature of the room during the test was 81° to 89° F.

The bacteria were exposed as follows :

	Garden earth.	Subtilis spores.	Anthrax spores.	Staphy- lococcus.	Pyocya- neus.	Icter- oides.
In envelopes, not sealed	+	—	—	—	—	—
In Petri dishes, open.....	+	—	—	—	—	—
In paper boxes.....	+	+	+	—	—	—

The mosquitoes were exposed as follows :

	Dead.	Alive.
In a battery jar—		
1. Covered with mosquito netting only.....	15	0
2. One-third full of crumpled toweling and tissue paper loosely tucked in to afford a hiding place.....	1	11
3. Two-thirds full of paper and toweling to afford a hiding place...	0	12
In pill boxes—		
1. Between sheets of a folded newspaper.....	0	2
2. Under 1 sheet of newspaper.....	8	0
3. Under 1 layer of dry toweling.....	6	0
4. Under 2 layers of dry toweling.....	1	2
5. Wrapped in 1 layer of damp toweling.....	7	0
6. Wrapped in 2 layers of damp toweling.....	6	1
7. Wrapped tightly in small damp towel.....	0	4
8. Wrapped twice in a damp towel and that covered with a dry towel	0	4
9. Stuck to wall with a damp towel hung directly over the box....	8	1
10. Same with a dry towel hung over it, 1 inch from box.....	14	0
11. Same with 2 dry towels hung over the box.....	8	0
12. In outside overcoat pocket, 8 inches deep.....	0	7
13. In inside pocket of overcoat.. ..	0	5
14. On floor, under 2 crumpled towels, piled in a heap.....	0	4
15. On floor under a pile of towels.....	0	2

The mosquitoes and the cultures were not exposed under precisely similar conditions, so that an exact comparison can not be drawn between the insecticidal and germicidal power of the gas in this test.

Here it is again evident from the tests made with the battery jars that the mosquitoes have the ability to protect themselves by seeking hiding places in the folds of the towel and tissue paper.

In this test the high percentage of the gas had sufficient germicidal power to kill all the non-spore-bearing organisms and many of the spores during the short exposure.

No. 10.

This test was made with the autoclave in the same room of 2,000 cubic feet capacity described above. The gas was allowed to pass into the room for fifteen minutes under a pressure of between 45 and 50 pounds to the square inch. As before, 2,000 c. c. (about 65 ounces) of the glyco-chloro-formol solution were used and 1,200 c. c. passed over, leaving a residue of 800 c. c. in the retort.

The time of exposure was nineteen hours, the temperature of the room being 75° to 85° F.

The mosquitoes and cultures were exposed in the small pill boxes under exactly similar conditions as follows:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes:				
Exposed to the gas without protection.....	5	0	+ <i>a</i>	—
Under 2 layers of dry toweling.....	5	0	+	—
Wrapped tightly in a dry towel, 8 layers.....	6	0	+ <i>a</i>	—
Under 2 layers of damp toweling.....	8	0	— <i>b</i>	—
Wrapped tightly in a damp towel, 8 layers.....	2	3	+	—
In pocket of a linen coat, hung on wall.....	4	0	+	—
In pocket of duck trousers, folded and laid on floor with pocket down.....	2	3	+	—
In pocket of trousers, hung up, pocket to wall.....	1	3	+	—
In corner of a folded newspaper, under 7 layers.....	4	0	+	—
Under 1 yard of toweling, heaped loosely in a pile.....	0	5	+ <i>a</i>	—
In canvas mail sack, mouth tied.....	6	0	+	—
In bottom of a battery jar under 2 layers of toweling.....	7	0	+	—

a Delayed.

b Contaminated.

Here an excess of about 3 times the usual amount of formalin solution was used, and the time of exposure was nineteen hours. Under these severe conditions, most of the mosquitoes succumbed. The only survivors were found under exceptionally severe conditions, such as under a heap of towels, or through 8 layers of moist towels, or in the pocket of trousers, folded and laid on the floor with the pocket down. The gas penetrated in sufficient strength to destroy all the non-spore-bearing bacteria exposed under precisely the same conditions in boxes alongside those containing the mosquitoes. None of the dry spores were killed.

It is evident from these tests with the autoclave that the time of exposure is a very important factor in obtaining penetration of the gas to the insects protected in fabrics, etc.

Large percentages of gas for a short time will not penetrate; neither do the conditions prescribed by the United States quarantine regulations appear to be effective in penetrating to insects deeply hidden, while the long exposures to a large percentage of gas gives but moderately satisfactory results, as far as penetration is concerned. The mosquitoes directly exposed to any of these conditions are all killed in a very short time.

While it is by no means absolute, the similarity between the resistance of spores and mosquitoes to formaldehyd disinfection is very striking. In other words, to be sure of killing mosquitoes in an ordinary room, containing fabrics where the insects may hide, we must use a concentration of the gas and a length of exposure sufficient to kill a spore-bearing organism.

SULPHUR DIOXID.

In order to compare the merits of formaldehyd with sulphur dioxid gas in disinfection against mosquitoes, similar experiments were made by burning sulphur and with the liquid sulphur dioxid gas.

The power of sulphur dioxid to destroy all forms of animal life is well known. On account of its destructive action upon fabrics and metals, this agent is of little practical use in the disinfection of dwelling houses, cabins of ships, and similar places. This destructive action is due to the moisture which combines with the sulphur dioxid to form sulphurous acid, which is the real disinfecting agent. Dry sulphur dioxid has practically no effect upon bacteria. Our work has shown that very small atmospheres of the dry gas will quickly destroy mosquitoes, and we therefore believe that the destruction of these insects may be accomplished in dwelling houses with little danger of injuring fabrics or tarnishing metals. Sulphur dioxid is so far superior to formaldehyd as an insecticide that even this risk should not outweigh the certainty of its action. The gas may now be obtained in its liquefied form, either in tin cans, in syphons, or in iron cylinders, affording very convenient methods of quickly introducing a given amount of the dry gas into an inclosure.

No. 11.

Two pounds of sulphur were burned in a small room with a capacity of exactly 500 cubic feet. This gives nearly the prescribed 4 per cent of gas. The room was specially built for experiments with gaseous disinfectants and is made very nearly air-tight. The time of exposure was four hours.

The sulphur was in the form of "flowers." It was burned in a small pot and the fire started with alcohol.

Mosquitoes were exposed in the small pill boxes with gauze lids, as follows :

In pill boxes—	Dead.	Alive.
Under 1 layer toweling.....	4	0
Under 2 layers toweling.....	7	0
Under 4 layers toweling.....	4	0
Wrapped twice in towel.....	3	0
Covered with 1 sheet newspaper.....	5	0
In corner folded newspaper.....	5	0
In inside pocket of overcoat.....	3	0
On wall back of coat.....	4	0
On wall back of 3 towels.....	4	0
On floor under several loose towels.....	4	0
In battery jar one-third full crumpled toweling.....	12	0

No bacteria were exposed in this test. The result showed that the prescribed amount of sulphur will kill the insects in a much shorter time than is required to destroy bacterial infection, and that the sulphur dioxid possesses considerable penetrating power in this short time.

No. 12.

In the same room of 500 cubic feet capacity 330 grams of sulphur (about one-third the prescribed amount) were burned, and the room was left closed twenty-four hours. Mosquitoes were exposed and with some of them subtilis spores, fresh garden earth, and pyocyaneus germs were exposed in boxes under similar conditions, as follows:

	Mosquitoes.		Bacteria.		
	Dead.	Alive.	Garden earth.	Subtilis spores.	Pyocyaneus.
In pill boxes:					
On floor, no protection.....			+		
Under heavy carpet.....				+	
On shelf, no protection.....			+		
On rafter near ceiling, no protection.....			+		
In corner, folded newspaper.....	6	0		+	
Under 4 thicknesses toweling.....	6	0		+	
In mail sack half full of crumpled paper.....	7	0			
Under 8 layers dry toweling.....	5	0			
Under 4 layers damp toweling.....	5	0			
Under 8 layers damp toweling.....	5	0			
In pocket duck trousers, rolled up.....	6	0			
Rolled 4 times in damp towel and put in coat pocket.....	6	0			
On floor under empty wooden box.....	5	0			

This small amount of the gas killed all mosquitoes and non-spore-bearing organisms even under conditions requiring deep penetration.

No. 13.

These results with sulphur dioxid were so good that another test was made to see whether a very small amount of sulphur with a short exposure would be sufficient to kill mosquitoes and leave the non-spore-bearing organisms unharmed.

To this end about 6 ounces (191 grams) of sulphur were burned by the pot method in a room of just 500 cubic feet capacity. The room was aired one hour after the sulphur was lighted, so that the total exposure to the gas was one hour.

The mosquitoes and the cultures were exposed in the pill boxes with gauze lids, under similar conditions, as follows:

	Mosquitoes.		Cultures.
	Dead.	Alive.	Pyocyaneus.
In pill boxes:			
One shelf without protection.....	4	0	+
On high rafter, no protection.....	4	0	+
Under 1 layer damp toweling.....	4	0	+
Under 2 layers damp toweling.....	4	0	+
Under 4 layers damp toweling.....	4	0	+
Wrapped in damp towel, 4 layers.....	3	0	+
Wrapped in damp towel, 8 layers.....	0	4	+
Wrapped in dry towel, 4 layers.....	4	0	+
On floor under a dirty sheet.....	2	3	+
On floor under a wooden box.....	0	4	+

It is plain that very weak percentages of sulphur dioxid are sufficient to kill mosquitoes in a short time, even though protected by 4 layers of

toweling. None of the cultures were killed. Sulphur dioxid has always been regarded as merely a surface disinfectant against bacterial infection. The results of all who have tested the gas are unanimous in concluding that it has very feeble powers of penetration. Its effect upon mosquitoes is in striking contrast to its bactericidal action in this regard.

EXPERIMENTS WITH LIQUID SULPHUR DIOXID.

No. 14.

One tin can containing 20 ounces of liquid sulphur dioxid gas was opened in the room containing 500 cubic feet. The temperature in the room was 29.3° to 30° C. Exposure eighteen hours. One of these 20-ounce cans is supposed to suffice for 1,728 cubic feet, so that the amount used was about three and a half times that required for bacterial disinfection.

The mosquitoes and the cultures were exposed in the pill boxes with gauze lids, under similar conditions, as follows :

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyaneus.
In pill boxes:				
On floor, under carpet.....	6	0	+	—
In canvas mail sack, folded.....	8	0	+	—
In pocket, duck coat, hung up.....	7	0	+	—
In pocket, cloth trousers, hung up.....	7	0	+	—
Under 2 layers, dry toweling.....	6	0	+	—
Under 2 layers, damp toweling.....	5	0	+	—
Wrapped tightly in dry towel, 7 layers.....	5	0	+	—
Wrapped tightly in damp towel, 7 layers.....	5	0	+	—
In coat pocket, hung up, flap closed.....	4	0	+	—
In bottom 12-inch beaker, covered with 2 layers toweling...	6	0	+	—
In corner folded newspaper, under 7 layers.....	7	0	.....	.....

The moisture of the atmosphere during this test was determined by drawing the atmosphere over calcium chlorid. The gain in weight showed the presence of 0.2692 grams of moisture per liter.

No. 15.

A second test with the liquid sulphur dioxid was made. The conditions were precisely similar to those of the preceding experiment, No. 14, excepting that moisture in the form of steam was injected through the keyhole after the gas was liberated. The temperature of the room during the exposure was 29.3° to 30° C. The atmosphere was saturated with moisture.

The mosquitoes and the cultures were exposed in the pill boxes with gauze lids, under similar conditions, as follows:

	Mosquitoes.		Bacteria.	
	Dead.	Alive.	Subtilis spores.	Pyocyanus.
In pill boxes:				
On floor, under carpet.....	7	0	+	—
In canvas mail sack, folded.....	5	0	+	—
In pocket duck coat, hung up.....	5	0	+	—
In pocket cloth trousers, hung up.....	5	0	+	—
Under 2 layers dry toweling.....	9	0	Lost.	—
Under 2 layers damp toweling.....	7	0	+	—
Wrapped tightly in dry towel, 7 layers..	6	0	+	—
Wrapped tightly in moist towel, 7 layers..	7	0	+	—
In coat pocket, hung up, flap closed.....	6	0	+	—
In bottom of 12-inch beaker covered with 2 layers of towel..	7	0	+	—
In corner of folded newspaper, under 7 layers..	8	0	+	—

The results were the same as No. 14, viz, death of all mosquitoes, even when well protected by dry or moist fabrics; the death of fresh moist cultures of pyocyanus, and the failure to affect subtilis spores similarly protected.

No. 16.

A series of experiments was made to determine whether chemically dry sulphur dioxid has insecticidal properties. It is well known that the anhydrous gas has practically no effect upon bacteria. As the dry gas is not destructive to fabrics and metals, it is of considerable practical importance to know whether it will kill mosquitoes.

To this end the liquid sulphur dioxid was liberated in a bell jar, but first passed through 2 drying columns containing pumice stone saturated with sulphuric acid. The moisture contained in the air of the bell jar was eliminated in 2 ways, (1) by drawing air through the drying columns into the bell jar, or (2) by introducing calcium chlorid into the bell jar.

It was found, in all these tests, that the mosquitoes were killed, practically, instantly by the dry gas.

Contrary to formaldehyd, which requires an exposure and strength of gas sufficient to destroy spores in order to entirely rid a room of mosquitoes, sulphur dioxid will kill these insects even when the quantity of the disinfectant and the time of exposure are reduced so that non-spore-bearing bacteria are unharmed.

Sulphur dioxid was for a long time used as a disinfecting agent against yellow fever, and experience found it to be trustworthy. But later it was disparaged because laboratory tests showed that it lacked the power of killing spores and has little penetrating power through fabrics. But now that we know it is the mosquito which carries the infection, the usefulness of this agent is revived.

SUMMARY AND CONCLUSIONS.

FORMALDEHYD GAS is a feeble insecticide. Mosquitoes may live in a very weak atmosphere of the gas overnight. It will kill them, however, if it is brought in direct contact in the strength and time prescribed for bacterial disinfection. For this purpose any of the accepted methods for evolving the gas is applicable, but the methods which liberate a large volume in a short time are more certain than the slower ones.

Direct contact between the insects and the gas is much more difficult to obtain in ordinary room disinfection against mosquitoes than against germs, because the sense of self-protection helps the former to escape from the effects of the irritating gas. They hide in the folds of towels, bedding, clothing, hangings, fabrics, and out-of-the-way places where the formaldehyd gas does not penetrate in sufficient strength to kill them. The gas is polymerized and deposited as paraform in the meshes of fabrics, which prevents its penetration, and large quantities are lost by being absorbed by the organic matter of fabrics, especially woollens. In our tests, whenever the insects were given favorable hiding places, such as in crumpled paper or in toweling, they quickly took advantage of the best place for themselves and thus escaped destruction.

There is a striking analogy between the strength of the gas and the time of exposure necessary to penetrate the fabrics in order to kill mosquitoes, and the strength and time necessary to penetrate in order to kill the spores of bacteria.

Mosquitoes have a lively instinct in finding cracks or chinks where fresh air may be entering the room, or where the gas is so diluted that they escape destruction. They are able to escape through incredibly small openings. Some of the smaller varieties, such as the *stegomyia fasciata* can get through a wire screen having 12 meshes to the inch. Therefore, formaldehyd gas can not be trusted to kill all the mosquitoes in a room which can not be tightly sealed.

It is concluded, that to succeed in killing all the mosquitoes in a closed space with formaldehyd gas, the following definite requirements are essential: A very large volume of the gas must be liberated quickly, so that it may diffuse to all portions of the space in sufficient concentration. The room must have all the cracks and chinks where the insects may breathe the fresh air carefully sealed by pasting strips of paper over them. The room must not contain heavy folds of drapery, clothing, bedding, or fabrics in heaps, or so disposed that the insects may hide away from the full effects of the gas.

SULPHUR DIOXID is unexcelled as an insectide. Very dilute atmospheres of the gas will quickly kill mosquitoes. It is quite as efficacious for this purpose when dry as when moist, whereas the dry gas has practically no power against bacteria. Contrary to formaldehyd it has sur-

prising powers of penetrating through clothing and fabrics, killing the mosquitoes, even when hidden under 4 layers of toweling, in one hour's time—and with very dilute proportions.

This substance, which has so long been disparaged as a disinfectant because it fails to kill spores, must now be considered as holding the first rank in disinfection against yellow fever, malaria, filariasis, and other insect-borne diseases.



MAY, 1902.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.



BULLETIN No. 7 OF THE HYGIENIC LABORATORY,

Treasury Department, U. S. Marine-Hospital Service,

WALTER WYMAN, Surgeon-General.

MAY, 1902.

LABORATORY TECHNIQUE.

RING TEST FOR INDOL,

S. B. GRUBBS AND EDWARD FRANCIS.

COLLODIUM SACS,

S. B. GRUBBS AND EDWARD FRANCIS.

MICROPHOTOGRAPHY WITH SIMPLE APPARATUS,

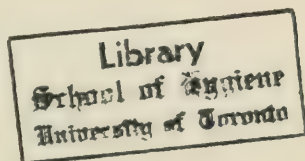
H. B. PARKER.

M. J. ROSENAU,

Passed Assistant Surgeon, Director Hygienic Laboratory,

U. S. MARINE-HOSPITAL SERVICE,

WASHINGTON, D. C.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1902.

RING TEST FOR INDOL.

(BY S. B. GRUBBS, PASSED ASSISTANT SURGEON, AND EDWARD FRANCIS, ASSISTANT SURGEON,
UNITED STATES MARINE-HOSPITAL SERVICE.)

The method of applying the indol test, as ordinarily used in laboratories and described in our text-books, is certainly crude, and consequently the statement that an organism does or does not produce indol leaves us in most cases very uncertain as to just what is meant.

As we know, the line between the indol producers and non-producers is not distinct, and several organisms "not producing indol" do give the reaction if grown long enough in suitable media. Thus, for example, we can get a faint but distinct reaction from cultures of *Bacillus pestis* and *Bacillus typhosus*, although these organisms under ordinary conditions are not considered indol producers.

So we must draw the line arbitrarily, and in this laboratory we take cultures grown twenty-four hours at 37° C. in media containing 1 per cent of peptone and use the ring or contact test, allowing it to remain in contact one hour.

We have applied the ring test in determining the presence of indol on account of its simplicity, its clearness, and its delicacy. When the acid and solution of nitrites were mixed, we found the color reaction was often unsatisfactory, the natural yellow tint masking the pink, or the color appearing on first contact with the nitrite solution would disappear when the tube was shaken.

The following technique will always give a clear-cut reaction if indol is present, or if not, there is no difficulty in deciding in the negative:

To 7 c.c. of the twenty-four-hour culture add 8 to 10 drops of concentrated sulphuric acid and shake; then let 3 or 4 c.c. of a 1-1000 sodium-nitrite solution run carefully down the side of the tube so as to form a sharp line of contact between the heavier culture and acid and the lighter nitrite solution, when the pink color will contrast sharply with the portions above and below.

The adoption of this technique, with the time limits mentioned, will make the indol reaction very clear in its results and will increase its value as a means of recognizing species.

COLLODIUM SACS.

(BY S. B. GRUBBS, PASSED ASSISTANT SURGEON, AND EDWARD FRANCIS, ASSISTANT SURGEON,
UNITED STATES MARINE-HOSPITAL SERVICE.)

Since the publication of the work of Metchnikoff, Roux, and Salimbeni¹ on the toxins of cholera, the growing of cultures in collodium sacs placed in the peritoneal cavities of animals has become a common procedure not only at the Pasteur Institute, but in all bacteriological laboratories when it is desired that the culture in its growth shall be raised in virulence through the action of the nutrient body fluids and yet be protected from the influence of the body cells and phagocytes.

As usually made, the sac is molded over the end of a glass rod by dipping it several times into the collodium solution, after which it is peeled off (Pasteur Institute).

Novy² slips inside the sac a glass tube which is perforated and constricted, and he fixes the free border of the sac to the glass tube at a point just below the constriction by means of heat, pressure, a silk ligature, and additional collodium.

McCrae,³ following Prudden, employs a glass tube, to the heated end of which he attaches a gelatin capsule which acts as a temporary frame over which the collodium is molded. The capsule is then removed by dissolving it in hot water.

In the techniques just referred to there are several delicate manipulations which greatly hazard the chances of getting a perfect sac:

1. There is the danger of tearing and destroying the sac in peeling it off the rod.

2. There is considerable difficulty in attaching the sac securely to the glass frame; and,

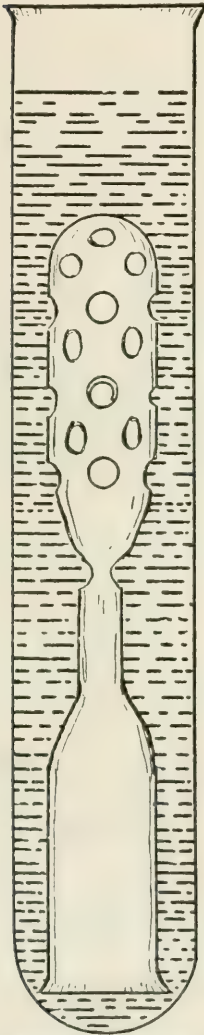
3. If no frame is used, the sac has no support, may become shriveled, and is liable to tear on removal from the animal's abdominal cavity if bound around by adhesions.

¹Toxine et antitoxine cholérique Ann. de l'Institut Pasteur 1896, X.

²Laboratory work in bacteriology.

³Journal of Experimental Medicine, vol. 5.

In endeavoring to overcome these difficulties we have hit upon the following simple technique and have used it repeatedly in the Hygienic Laboratory for several months;



The glass frame inclosed in a test tube of hot water to remove the gelatin from the perforations.

The sac is molded in the very beginning over the perforated glass frame, from which it is not later removed.

The steps are as follows:

A glass frame is first made according to the method of Novy. Eight to twelve openings, each having a diameter of about $\frac{1}{8}$ inch, are blown as closely as possible in the lower part of a small test tube, the size and number of the holes depending on the amount of osmosing surface desired.

The tube is then partially constricted in the flame at a point just above the openings. The constriction is of such size as to admit a fine pipette for inoculation. Some pure gelatin, to which is added a little water, is liquefied by heat, and with a glass rod a drop of the hot gelatin is applied to each individual opening in the glass frame, which, when it solidifies, forms a thin film which temporarily closes each perforation.

The tube is now dipped two or three times into the collodium solution to a point well above the openings but below the constriction. In order to remove the gelatin film from the holes, the tube is filled with water and it is inverted in a larger tube or beaker of water the temperature of which is raised until the gelatin melts and runs down the inside of the tube through the constricted part and out into the water (see cut).

We then have the collodium firmly adherent to the glass frame, covering its openings, well supported and ready to stand, without tearing or leaking, the manipulations of sterilization, filling, inoculation, sealing, implantation and removal from the abdominal cavity.

The ease with which this technique can be carried out will, we think, appeal to those who have had experience with other methods.¹

¹ The glass frame may be further improved by directing the gas blast flame against the tube on opposite sides just below the constriction until the glass becomes softened and indented. These two flattened surfaces afford a good place for grasping the frame with a pair of forceps during the sealing off and implantation. This overcomes the slipping and turning which occur on attempting to hold firmly a perfectly round tube.

MICROPHOTOGRAPHY WITH SIMPLE APPARATUS.

(BY H. B. PARKER, ASSISTANT SURGEON, UNITED STATES MARINE-HOSPITAL SERVICE.)

The art or mechanics of photography has in the last few years become very useful in pathological, histological, and bacteriological work. Almost every laboratory is supplied with an approved apparatus, while the independent workers convert their photographic apparatus, either kodak or camera, into some form of apparatus to meet their particular desires or needs. As a reward for their efforts they meet with varying degrees of success, so much so that in modern medical literature it is impossible in many instances to determine from the results whether the writer had in his possession an approved model or a simple makeshift of his own.

With low diameters almost any combination of microscope, camera, and illuminant will produce a fair picture in the hands of an amateur familiar with outdoor photographic processes. To obtain success with the higher diameters special apparatus is required, and these, I regret to say, are so expensive and difficult of manipulation that their use is prohibited in any but the more luxuriously equipped laboratories. The average size of the picture desired in bacteriological work is 2 inches; for pathological work somewhat larger; the average size of the plate in the modern microphotographic outfit is $6\frac{1}{2}$ by $8\frac{1}{2}$ inches to 8 by 10 inches with a bellows extension that will average 5 feet. This long extension was for a time an advantage, permitting the use of low-power objectives, amplification being secured by distance, but with the advent and perfection of apochromatic objectives, compensation and projection oculars, and instruments of greater precision in sectioning pathological and histological processes, the use of the long bellows is practically limited to achromatic and specially devised photographic objectives. A disadvantage probably more prominent than the preceding is the necessity of an arc light with its elaborate system of condensers and absorbing cells as the illuminant, a system too complex for the small and moderate size laboratory.

To overcome some of the disadvantages mentioned we have constructed an apparatus on the usual principle of the horizontal instrument but have reduced the size of the bellows extension to 32 inches and the size of the plate to 4 by 5 inches. We used an ordinary lantern-slide camera, which gave the results shown in the illustrations.

DESCRIPTION OF THE APPARATUS.

Success in microphotographic work depends largely upon the illuminant, of which there are six for consideration: Sunlight, the electric arc light, the oxyhydrogen light, illuminating gas, coal oil, and acetylene. Sunlight gives excellent photographs but is excluded on account of the expensive apparatus and special requirements for good work. The electric arc gives excellent results and is necessary when magnifications above 1,500 diameters are desired. The oxyhydrogen light, illuminating gas, and coal oil are too feeble for any but low diameters. Acetylene, because of its brilliancy, high actinic properties, low heat reflection, portability, low cost, and adaptability to other laboratory work, is the illuminant par excellence for diameters up to and including 1,500, for low-power microscopic projection, and lantern-slide projection.

The illuminating apparatus in use at this laboratory consists of a generator large enough to furnish gas for a quadruple burner, two condensers, of 4-inch focus, and a light filter and an absorbing cell holding a layer of water $\frac{1}{2}$ inch thick. The latter is sufficiently large to remove all heat rays as well as serving to hold water tinged with a color complementary to the stain employed on the specimen to be photographed.

The bellows as described above is one of the numerous models for lantern-slide work, either $3\frac{1}{4}$ by $4\frac{1}{4}$ or 4 by 5 inches.

The whole apparatus is mounted upon a firm base.

FOCUSING.

One of the most difficult features in connection with microphotographic work is focusing the object on the ground-glass screen. We have discarded the various focusing rods used for this purpose and now depend upon a braided twine, the center going around the fine adjustment and thence to the back of the camera, where it is kept taut by small weights. This has the advantage that when the focus is accurately found the ends can be released, removing the strain from the fine adjustment and consequently all interference with the focus. Rods clamped to the fine adjustment are apt to change the focus when released and are acted upon by vibrations of the room.

A magnifying glass of low magnification can be used as an aid in focusing with high diameters, but as a rule the focus of the entire field can be much more accurately gauged with the eye alone than with the aid of lenses.

EXPOSURE.

The length of exposure will depend upon the intensity of the image upon the screen and upon the rapidity of the plate. A

rapid exposure with an excess of light does not give the details which are obtained with less light and a longer exposure. In a general way then it may be said that the intensity of light should be subdued by reducing the diaphragm in the Abbe condenser until the exposure will approximately require about five seconds.

Care should be taken to see that no vibrations are produced during the exposure. This is best accomplished by selecting a time when the streets are free from passing vehicles, and all in the room should remain quiet. An ordinary pneumatic photographic shutter in the front board serves to reduce vibrations to a minimum and is far superior to the regular shutter supplied with these cameras.

CHOICE OF PLATES.

Only plates of double coating should be selected for this work, preferably one of the medium or slow grades.

They are distinguished from the ordinary plates by their isochromatic or orthochromatic qualities, giving correct color values with double-stained preparations—a property that can be increased by using a color screen complementary to the object to be photographed.

As a rule with these plates, no color screen is required with fuchsin, safranin, hæmatoxylin, or carmine.

Without reference to the complementary color, a color screen made with chromic acid or sulphate of copper, or both, combined in weak solution will answer for any color or combination of colors in general laboratory use.

DEVELOPMENT.

A good developer has the property of producing both detail and density. A single developer does not possess these qualities perfectly, so a combination is used.

Metol and hydrochinone about represent the extremes, but when combined in proper proportions give the best results in microphotographic work, as well as in general photography. The formula most used is the following:

R.

Metol	2.00
Hydrochinone	2.00
Sodium sulphite	20.00
Sodium carbonate	10.00
Potassii bromidi	0.25
Distilled water	500.00

M.

The metol and hydrochinone should be dissolved in the water before adding the sulphite. This preparation keeps indefinitely, and may be used until exhausted. Whatever the exposure, the development should be carried out until the plate is completely developed; errors in over exposure or under exposure may then be corrected by reduction or intensification, either process with full development producing a better negative than one poorly developed.

Formulæ containing a mercury salt, for intensification, or containing potassium ferricyanide, for reducing, usually accompany all makes of plates.

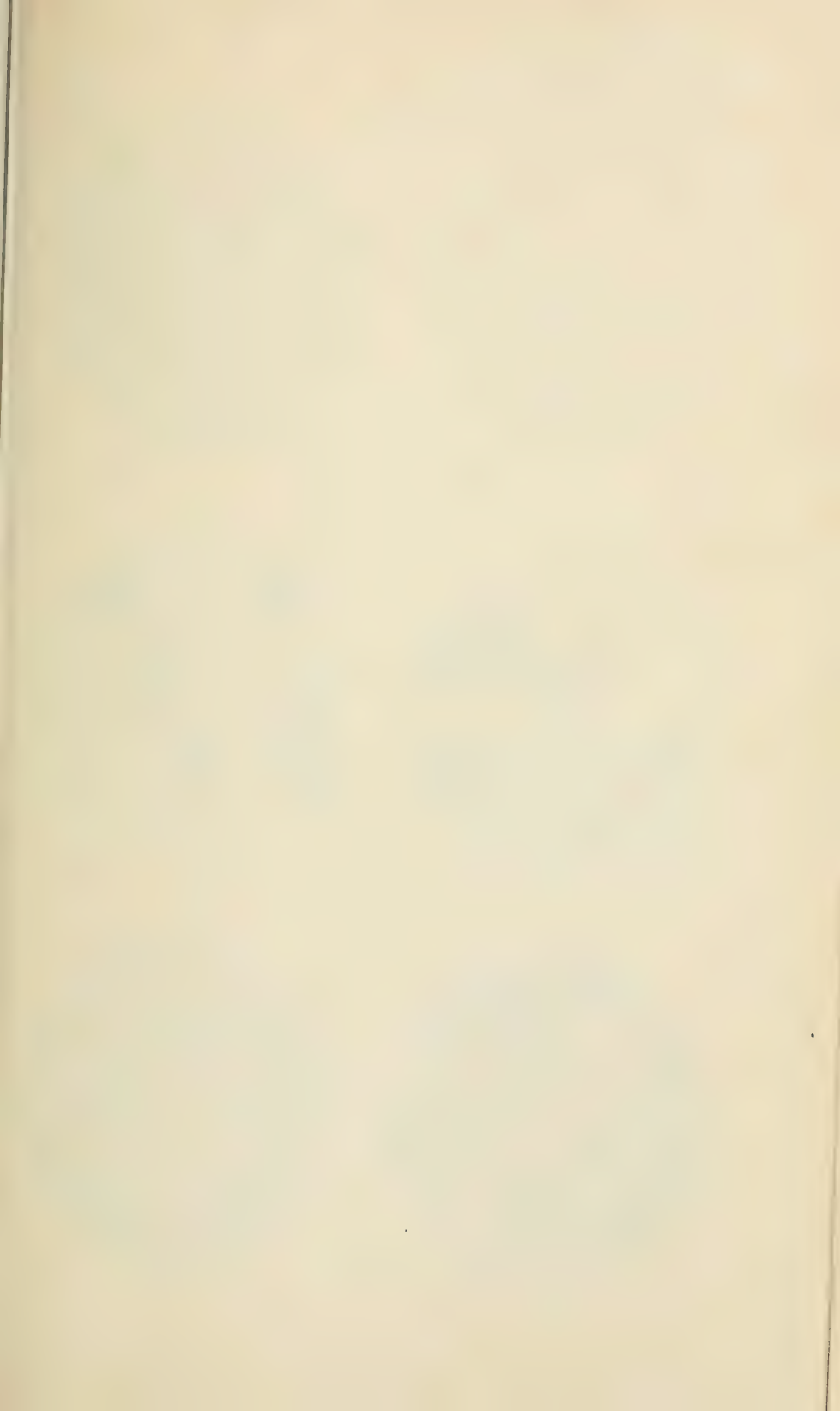
COST OF TEMPORARY AND PERMANENT APPARATUS.

The advantage of this apparatus is the low primary cost. A lantern-slide camera at a cost of \$10 makes an excellent bellows when firmly mounted on a frame. The generator, burner, two condensers and light filter would cost about \$25, making a total cost of about \$35.

A complete outfit with the necessary mechanical arrangements for centering the light, varying the focus of the condensers, and time shutter should be supplied for about \$60.

Where a laboratory is supplied with electricity, that illuminant may be used by substituting a hand-feed electric arc and a large absorbing cell at an increase in cost of \$5 to \$10.

With this apparatus and the well-known apochromatic objectives and projective oculars of Zeiss, it is possible to take a photograph of 1,000 diameters in two seconds, or about as rapidly as an exposure can be accurately made. For the low diameter the light is stopped down until the desired illumination is obtained. Our experience is that an exposure of five seconds for all magnifications gives greater detail than a more rapid exposure. In this time vibrations do not seriously interfere with sharpness of outline. A printing-out silver paper gives the best tone to a photograph when half-tone reproduction is desired. The finished print should be a shade darker, as density is always lost in the process of reproduction.



EXPLANATION OF PLATE No. 1.

1. Tetanus bacilli, with spores.
2. Typhoid bacillus, with flagella.
3. Plasmodium malarie, in human blood, crescentic forms.
4. Staphylococci in pus.
5. Normal kidney, mouse.
6. Vaccine bodies in cornea of rabbit.



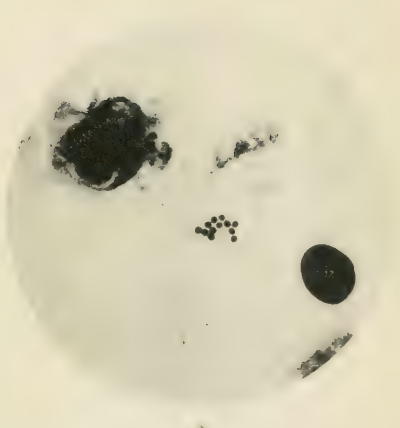
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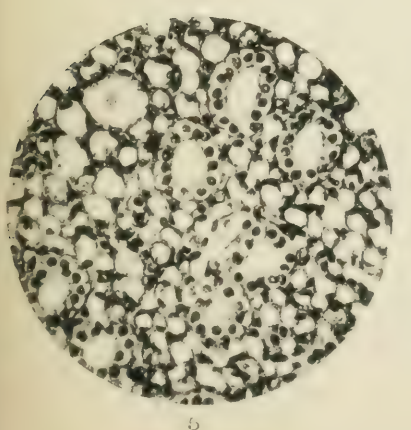
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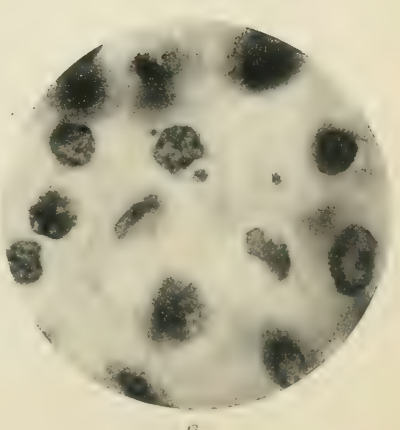
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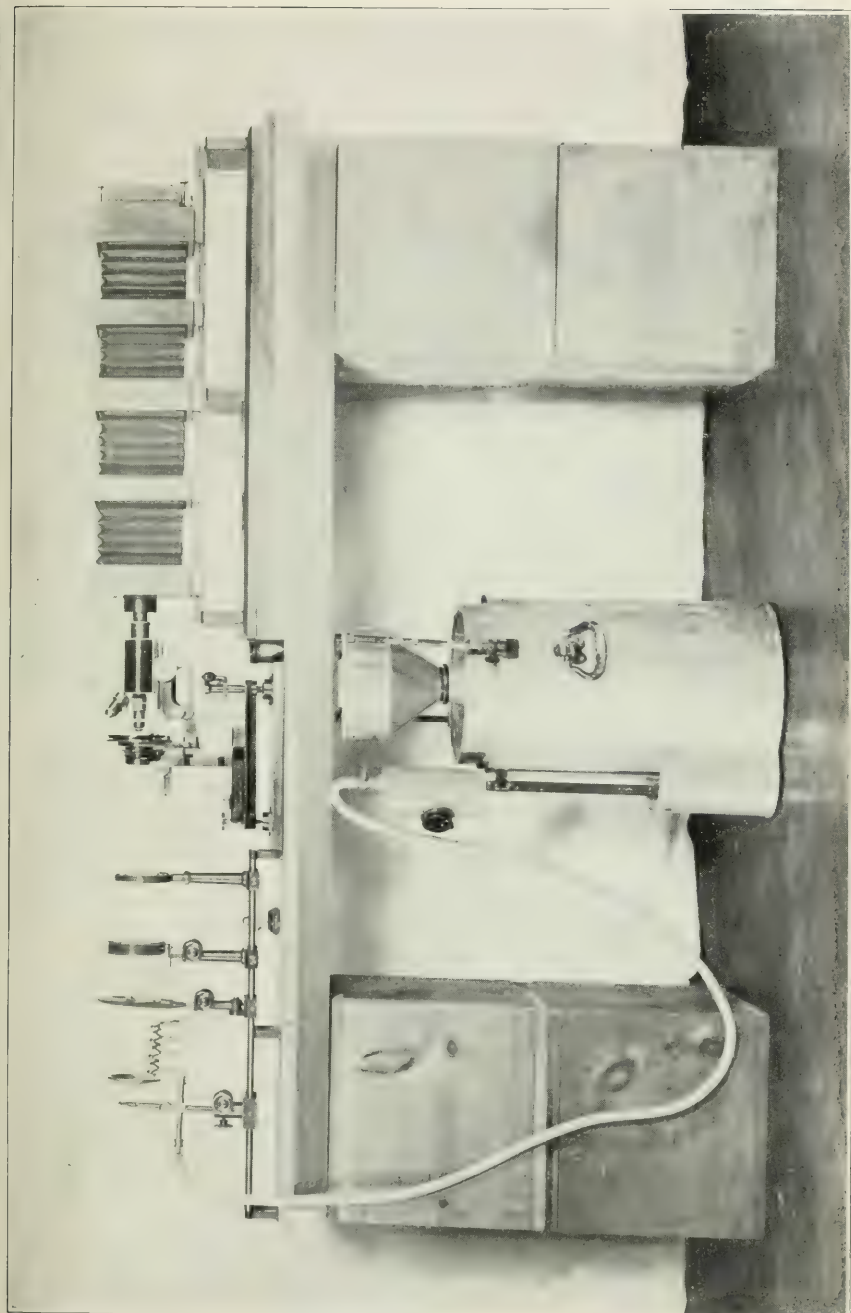
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HYG. 11111.
TREASURY DEPARTMENT.

Public Health and Marine-Hospital Service of the United States.

WALTER WYMAN, Surgeon-General

HYGIENIC LABORATORY.—BULLETIN No. 8.

MARCH, 1904.

LABORATORY COURSE

IN

PATHOLOGY AND BACTERIOLOGY

(REVISED EDITION)

BY

M. J. ROSENAU,

DIRECTOR OF HYGIENIC LABORATORY.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1904.

NOTICE TO LIBRARIANS AND BIBLIOGRAPHERS CONCERNING THE SERIAL PUBLICATIONS OF THIS LABORATORY.

The Hygienic Laboratory was established in New York, at the Marine Hospital on Staten Island, August, 1887. It was transferred to Washington, with quarters in the Butler Building, June 11, 1891, and a new laboratory building, located in Washington, was authorized by act of Congress, March 3, 1901.

The following *bulletins* [Bulls. Nos. 1-7, 1900 to 1902, Hyg. Lab., U. S. Mar.-Hosp. Serv., Wash.] have been issued:

- No. 1.—Preliminary note on the viability of the *Bacillus pestis*. By M. J. Rosenau.
- No. 2.—Formalin disinfection of baggage without apparatus. By M. J. Rosenau.
- No. 3.—Sulphur dioxide as a germicidal agent. By H. D. Geddings.
- No. 4.—Viability of the *Bacillus pestis*. By M. J. Rosenau.
- No. 5.—An investigation of a pathogenic microbe (*B. typhimurium* Danyz) applied to the destruction of rats. By M. J. Rosenau.
- No. 6.—Disinfection against mosquitoes with formaldehyd and sulphur dioxid. By M. J. Rosenau.
- No. 7.—Laboratory technique: Ring test for indol, by S. B. Grubbs and Edward Francis; Collodium sacs, by S. B. Grubbs and Edward Francis; Microphotography with simple apparatus, by H. B. Parker.

By act of Congress, approved July 1, 1902, the name of the "United States Marine-Hospital Service" was changed to the "Public Health and Marine-Hospital Service of the United States," and three new divisions were added to the Hygienic Laboratory.

Since the change of name of the service the bulletins of the Hygienic Laboratory have been continued in the same numerical order, as follows:

No. 8.—Laboratory course in pathology and bacteriology. By M. J. Rosenau. (Revised edition March, 1904.)

No. 9.—Presence of tetanus in commercial gelatin. By John F. Anderson.

No. 10.—Report upon the prevalence and geographic distribution of hookworm disease (uncinariasis or anchylostomiasis) in the United States. By Ch. Wardell Stiles.

No. 11.—Experimental investigation of *Trypanosoma lewisi*. By Edward Francis.

No. 12.—The bacteriological impurities of vaccine virus; an experimental study. By M. J. Rosenau.

No. 13.—A statistical study of the intestinal parasites of 500 white male patients at the United States Government Hospital for the Insane; by Philip E. Garrison, Brayton H. Ransom, and Earle C. Stevenson. A parasitic roundworm (*Agamomermis culicis* n. g., n. sp.) in American mosquitoes (*Culex sollicitans*); by Ch. Wardell Stiles. The type species of the cestode genus *Hymenolepis*; by Ch. Wardell Stiles.

No. 14.—Spotted fever (tick fever) of the Rocky Mountains; a new disease. By John F. Anderson.

No. 15.—Inefficiency of ferrous sulphate as an antiseptic and germicide. By Allan J. McLaughlin.

No. 16.—The antiseptic and germicidal properties of glycerin. By M. J. Rosenau.

No. 17.—Illustrated key to the trematode parasites of man. By Ch. Wardell Stiles.

No. 18.—An account of the tapeworms of the genus *Hymenolepis* parasitic in man, including reports of several new cases of the dwarf tapeworm (*H. nana*) in the United States. By Brayton H. Ransom.

In citing these bulletins, beginning with No. 8, bibliographers and authors are requested to adopt the following abbreviations: Bull. No. —, Hyg. Lab., U. S. Pub. Health & Mar.-Hosp. Serv., Wash., pp. —.

MAILING LIST.

The Service will enter into exchange of publications with medical and scientific organizations, societies, laboratories, journals, and authors. Its publications will also be sent to nonpublishing societies and individuals in case sufficient reason can be shown why such societies or individuals should receive them. All applications for these publications should be addressed to the "Surgeon-General, U. S. Public Health and Marine-Hospital Service, Washington, D. C."

TREASURY DEPARTMENT.

Public Health and Marine-Hospital Service of the United States.

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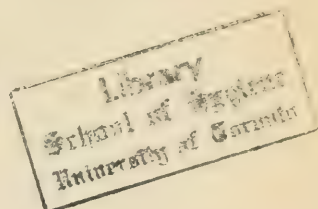
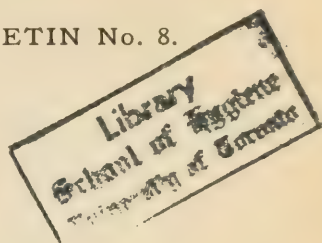
DIRECTOR OF HYGIENIC LABORATORY.



WASHINGTON:

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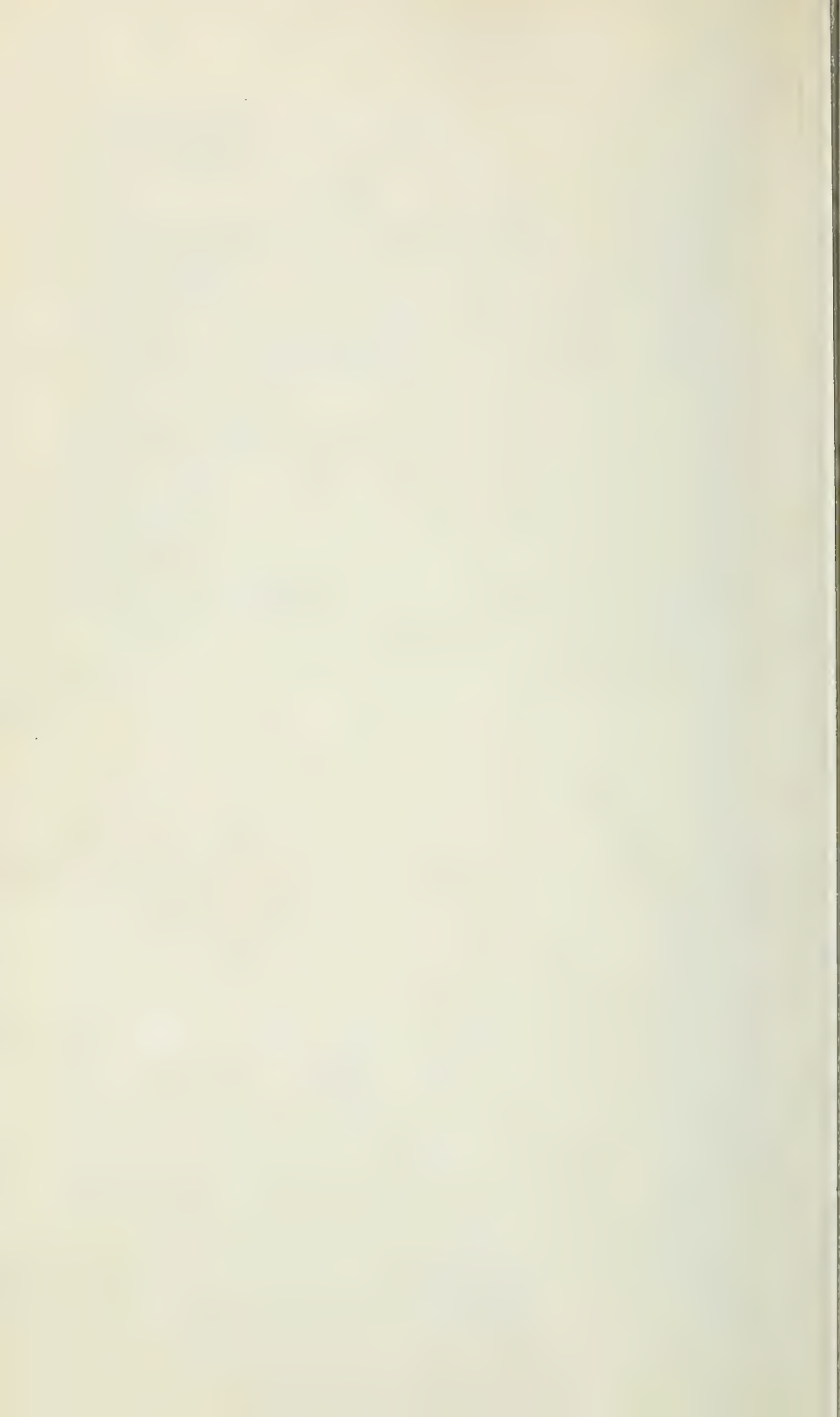
1904.



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PREFACE.

These pages contain a syllabus of the course in pathology and bacteriology given in this laboratory.

The object of the course is to thoroughly equip officers of the Service in the technique of pathology and bacteriology, in order better to fit them for the hospital, quarantine, epidemic, and public health work of the Service. Officers of the Service who have taken the prescribed course are thoroughly prepared to make a scientific diagnosis of plague, cholera, diphtheria, tetanus, tuberculosis, typhoid fever, anthrax, malaria, and other infectious processes, as well as to carry on original investigations for themselves.

The course as outlined requires one year for its completion. The student-officer is required to work each subject until he has mastered it before going to the next. Such deliberation permits a thoroughness that is not possible when work is hurried or limited to a short period of time.

Special courses.—A special course lasting three months is sometimes given to officers of the Service. This course deals especially with clinical bacteriology and pathology, and consists of the following subjects: Microscopical practice, making of culture media, bacteriological technique, the cutting and staining of pathological specimens, the study of tumors, the diagnosis of diphtheria, tuberculosis, cholera, typhoid fever, anthrax, plague, and malaria; the bacteriological examination of water, and the principles and practice of disinfection.

Another course lasting six months consists of the subjects as above, elaborated in many details. A more thorough study of the saprophytic bacteria is undertaken. A rapid review of histology and general pathology is given, and it also includes a more detailed study of the cultural and biological characteristics of the pathogenic bacteria. This course also includes the technique of blood examinations and the diagnosis of the more common animal parasites.

Modified courses are also given to officers who come to the laboratory well qualified by previous training in both pathology and bacteriology, but who desire to obtain the recent methods and improvements in these subjects, as well as to develop their knowledge in certain branches that have a particular bearing upon the public health.

The exact sequence as given on the following pages is not strictly adhered to, because it is the desire of the director to make the course as practical as circumstances will permit. Therefore, the study of diphtheria is usually left until the fall of the year or winter, when practical experience may be had with the cases which usually occur in the District. The studies upon vaccinia and smallpox are taken up during the winter months, which time is more apt to offer material and cases. Malarial work is of course largely confined to the summer and fall seasons.

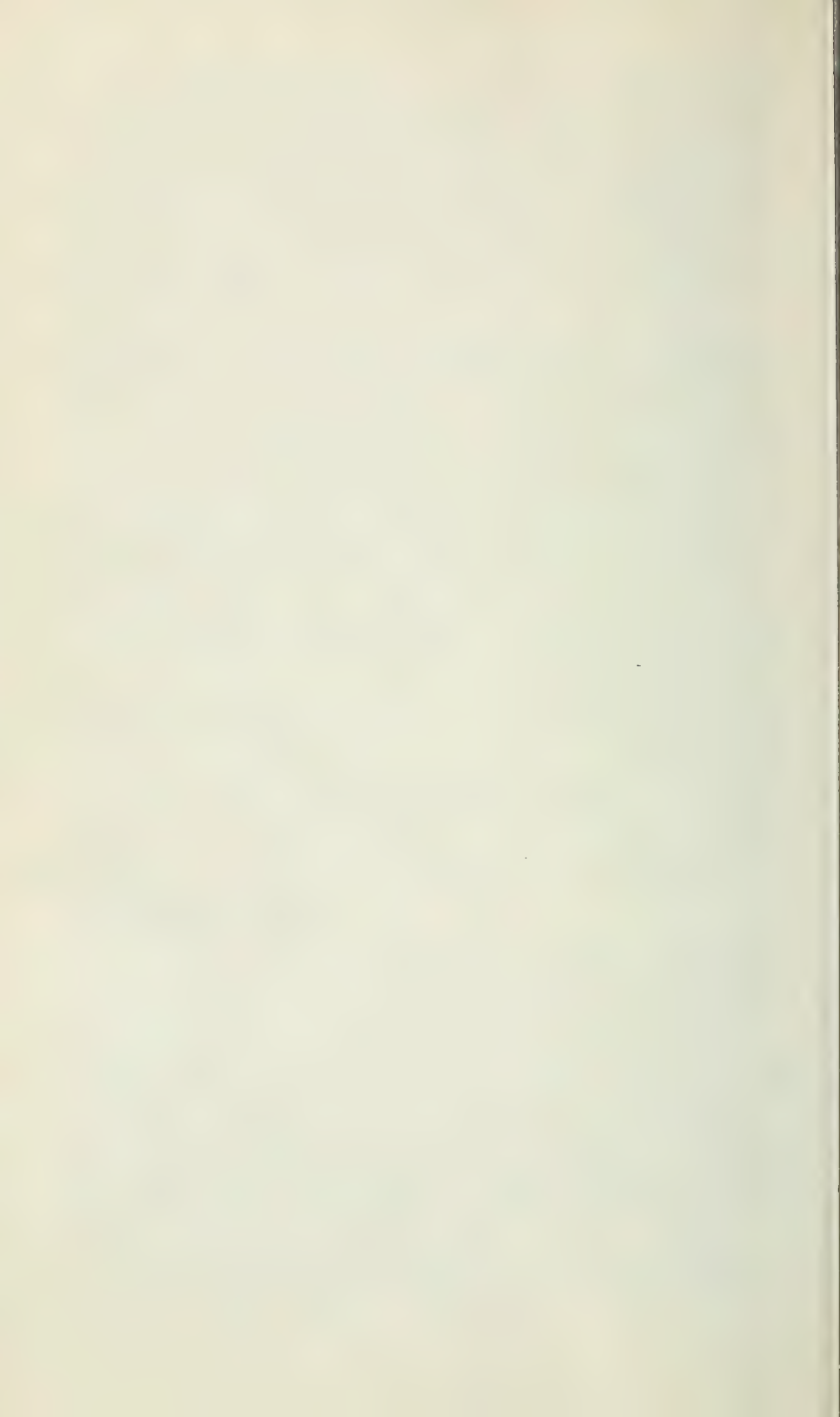
In connection with the health department of the District, the work of diagnosing diphtheria from swabs and culture tubes and the administration of antitoxin, both for prophylactic and curative purposes, is carried on by each student-officer. In connection with the studies upon vaccinia, a visit is always made to one of the large vaccine farms, which offers special advantages for observing the process of vaccinating the calves, obtaining the lymph and pulp, glycerinizing the virus, and preparing the product for market. In like manner advantage is taken, so far as it is practicable, of the material in hospitals and other institutions situated in the District of Columbia.

It will be noticed that in this edition more attention is given to the subjects of pathologic histology, and a short review in normal histology has also been added. A collection of tumors and pathologic processes has been obtained from various sources and these are cut, stained, mounted, and studied by each student-officer; and these specimens are used to demonstrate the quiz which is conducted by the director of the laboratory. The pathologic histology of all infectious processes upon the lower animals, which are studied in the laboratory, are thoroughly worked up by each student-officer in a systematic manner. Tumors and other specimens are received from time to time from the various hospitals and quarantine stations of the Service, and similar advantage is taken of such material.

In view of the growing importance of animal parasites in the causation of disease, a Division of Zoology has been added to the Hygienic Laboratory and the chief of this division gives each student-officer instruction in the various organisms of this class parasitic to man.

It will also be noticed that considerable importance is given to the subject of disinfection and disinfectants. This arises from the fact that officers of the Service are required not only in their hospital work, but more especially in their quarantine and public health duties, to thoroughly understand the theory and practice of this important subject. Each student-officer is required to master the theory and mechanics of all the important disinfecting apparatus and to make actual tests upon the efficiency and value of each one.

The scientific workers in the laboratory meet one evening each week in order to review the work of the week and to discuss the current

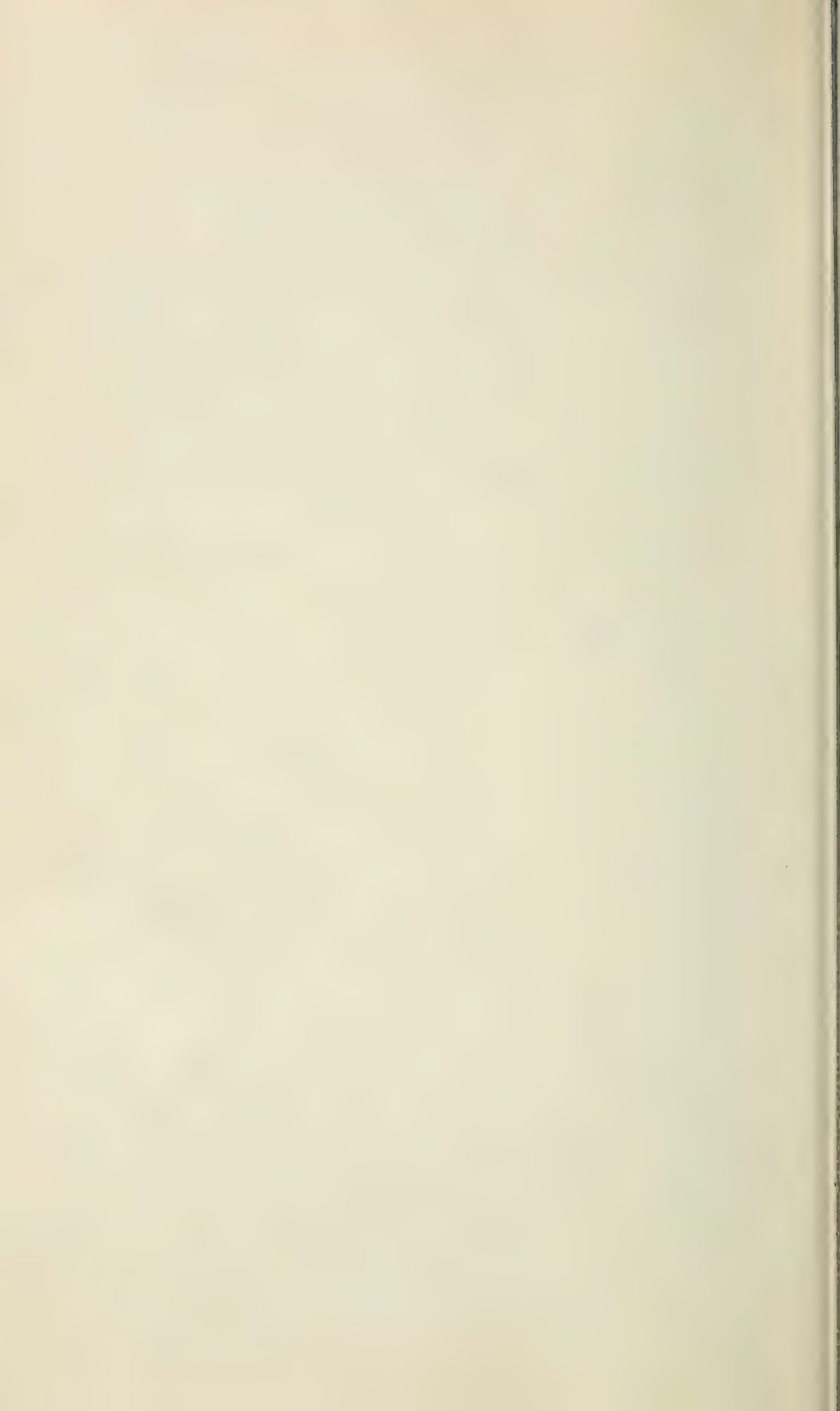


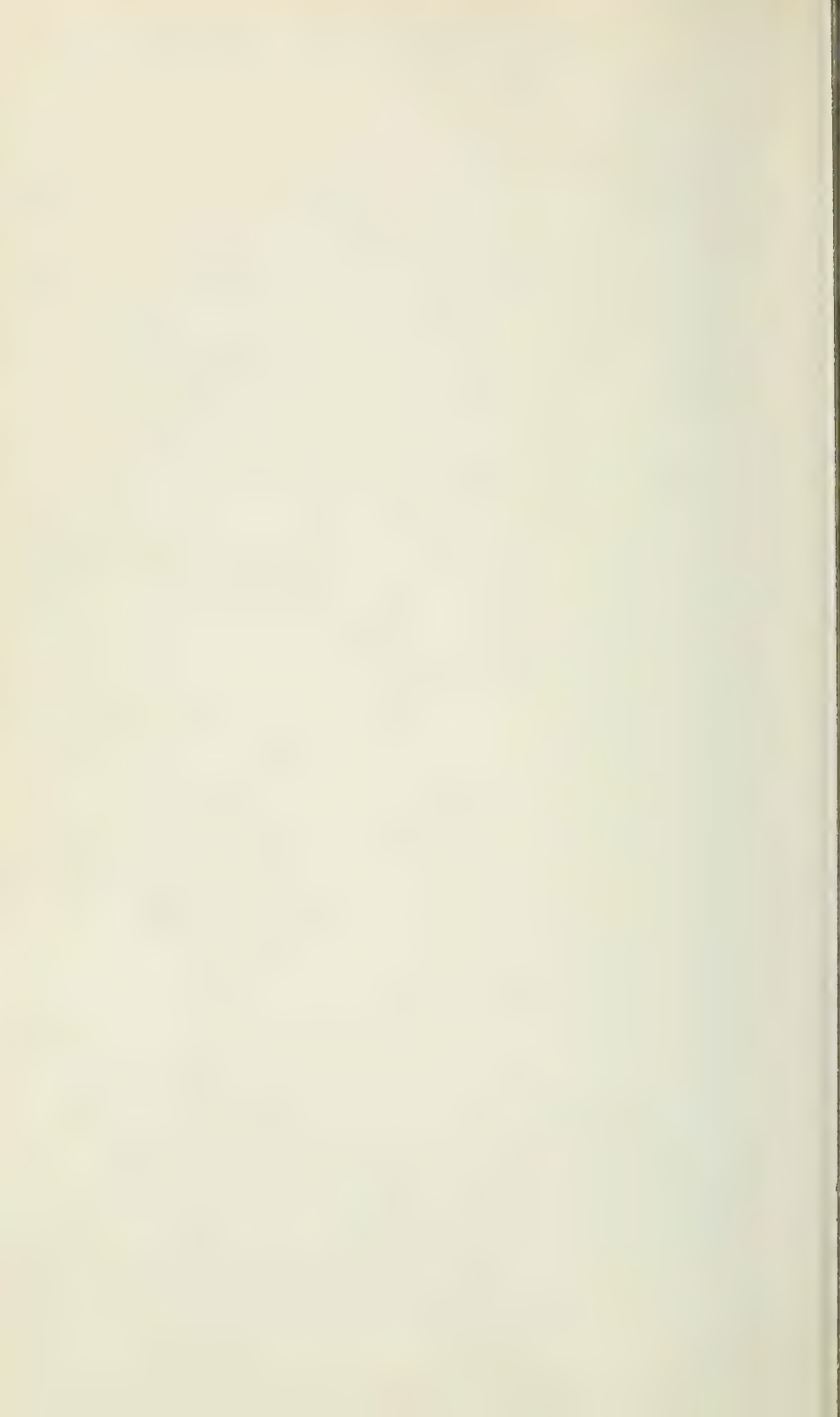
literature. The journals that are received are assigned to each student-officer, and it is his duty to present a critical review of important articles which he reads. We have found this an admirable plan for keeping thoroughly abreast with the large amount of literature constantly appearing, as well as a stimulus to thought and work.

In connection with this literary work each student-officer is encouraged to familiarize himself thoroughly with the use of the library facilities in Washington, in which this city offers unexcelled opportunities.

After the student-officer has been in the laboratory several months and has thoroughly acquainted himself with the necessary technique, opportunity is given him to assist with the work of the laboratory, and every encouragement is offered to work out original problems of his own.

The classes have been small, thus allowing for the individual equation of each student-officer, as well as a maximum of personal attention.





LABORATORY COURSE IN PATHOLOGY AND BACTERIOLOGY.

HYGIENIC LABORATORY,

United States Public Health and Marine-Hospital Service, Washington, D. C.

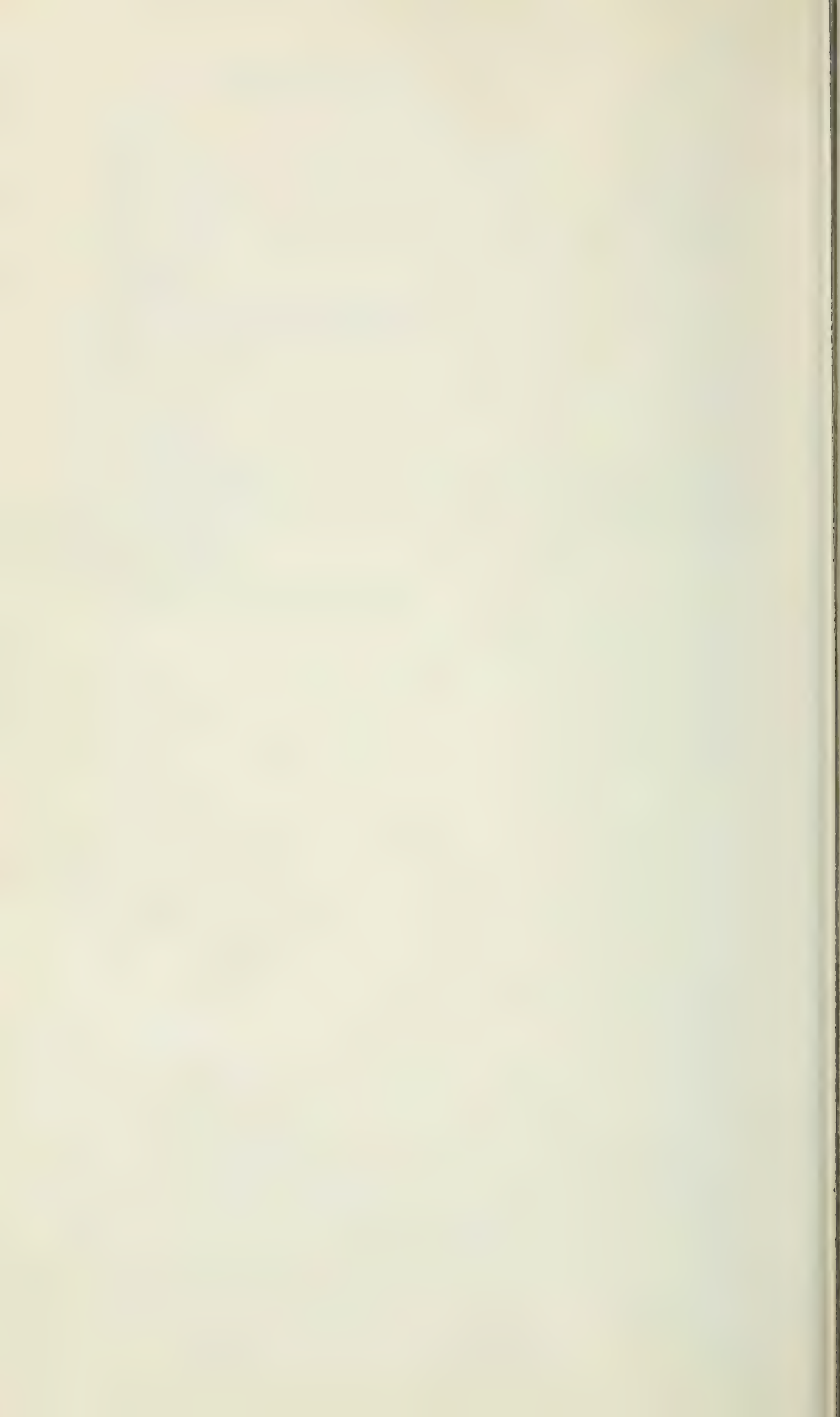
[By MILTON J. ROSENAU, Passed Assistant Surgeon and Director of the Hygienic Laboratory, United States Public Health and Marine-Hospital Service.]

PREPARATION OF MEDIA—

1. Bouillon:
 - a.* Acid.
 - b.* Neutral.
 - c.* Alkaline.
2. Sugar free bouillon (colon fermentation).
3. Glucose bouillon.
4. Lactose bouillon.
5. Dunham's solution.
6. Gelatin.
7. Agar-agar:
 - a.* Glycerin agar.
 - b.* Litmus agar.
8. Potato.
9. Blood-serum:
 - a.* Fluid.
 - b.* Coagulated.
 - c.* Löffler's blood-serum mixture.
10. Milk.
11. Litmus milk.
12. Aqueous humor of ox eyes.
13. Ascitic fluid.
14. Urine.

STUDIES FOR MICROSCOPIC PRACTICE—

1. Diatoms.
2. Algæ.
3. Protozoa.
4. Starch bodies.
5. Vegetable cells.
6. Cotton fibers.
7. Linen fibers.
8. Silk fibers.
9. Feathers.
10. Hair of man and of lower animals.
11. Scales of butterflies and of other insects.
12. Milk.
13. Air bubbles.
14. Oil drops.
15. Vinegar eels (*Anguillula aceti*).
16. Tube casts.
17. Ciliated epithelium.
18. Crystals of sugar, salt, uric acid, cholesterin, hematin, and various chemicals.
19. Decomposing meat.
20. Hay infusion.
21. Surface waters.
22. Opaque objects by reflected light.



POINTS TO BE OBSERVED IN DESCRIBING AN ORGANISM—

1. Its source.
2. Hanging drop. Form, size, grouping and motility.
3. Spores.
4. Staining peculiarities.
5. Flagella.
6. Appearance of colonies on gelatin, agar, blood-serum, potato, etc.
7. Relation to oxygen.
8. Growth on gelatin.
9. Growth on agar.
10. Growth on blood-serum.
11. Growth on potato.
12. Growth on fluid media:
 - a.* Bouillon—
 1. Acid.
 2. Neutral.
 3. Alkaline.
 - b.* Dunham's solution—indol.
13. Milk and litmus milk.
14. Reaction of media best suited to growth.
15. Changes in reaction of media.
16. Gas production:
 - a.* Glucose bouillon.
 - b.* Lactose bouillon.
 - c.* Saccharose bouillon.
 - d.* Mannite bouillon.
 - e.* Glucose agar.
 - f.* Glucose gelatin.
17. Temperature best suited to development.
18. Pathogenicity.
19. Reaction to sera of immune animals, antibodies, precipitins and agglutinins.
20. Toxins.

STUDY OF SAPROPHYTES

BACTERIA.

Genus *Bacillus* Cohn—

1. *Bacillus subtilis* (Ehrenberg, 1833) Cohn, 1872.
2. *Bacillus vulgaris* (Hauser, 1885) Migula, 1900. [*Proteus vulgaris*.]
3. *Bacillus megaterium* de Barry, 1884.
4. *Bacillus prodigiosus* (Ehrenberg, 1839) Flügge, 1886.

Genus *Pseudomonas* Migula—

5. *Pseudomonas fluorescens* Migula, 1900. [*Bacillus fluorescens liquefaciens* Flügge, 1886.]
6. *Pseudomonas aeruginosa* (Schröter, 1872) Migula, 1900. [*Bacterium aeruginosum* Schröter, 1872; *Bacillus pyocyaneus* Gessard, 1882.]

Genus *Planosarcina* Migula—

7. *Planosarcina agilis* (Ali-Cohen, 1889) Migula, 1900. [*Micrococcus agilis* Ali-Cohen, 1889.]

Genus *Sarcina* Goodsir—

8. *Sarcina lutea* Schröter, 1886.

Genus *Microspira* Schröter, 1886—

9. *Microspira aquatilis* (Günther, 1892) Migula, 1900. [*Vibrio aquatilis* Günther 1892.]

COMMON MOLDS—

Oidium.

Aspergillus.

Penicillium.

Mucor.

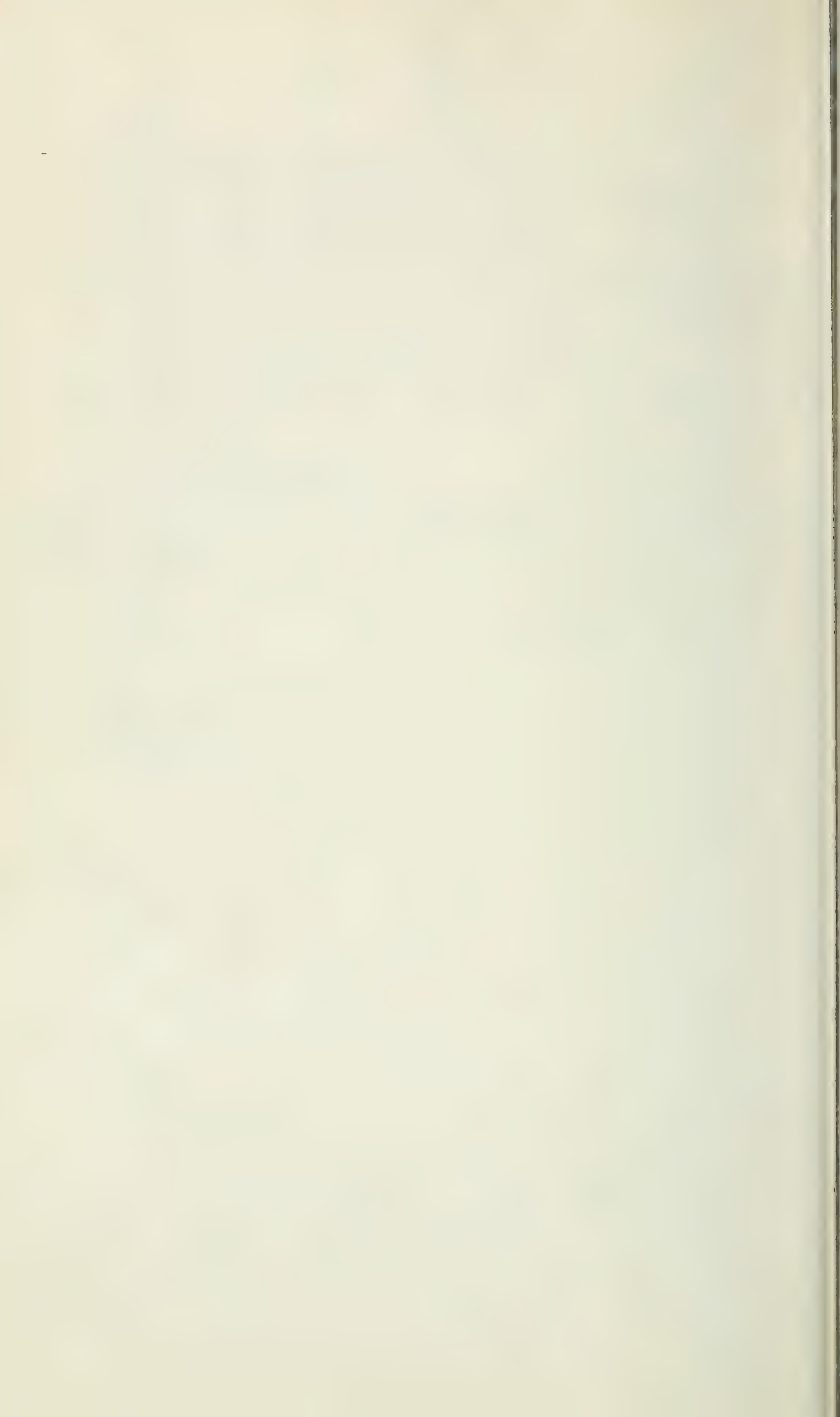
YEASTS—

Beer yeast (*Saccharomyces cerevisiae*).

Red yeast.

Black yeast.

Saccharomyces (*Torula*) *apiculatus*.



THE SYSTEMATIC POSITION OF BACTERIA.

LOWEST FORMS OF ANIMAL LIFE:

Class Ciliata—*Balantidium coli*.

Class Sporozoa—

Order Coccidiida—The oviform coccidium, *Eimeria stiedæ*.

Order Hemosporidia—Malarial parasites, *Plasmodium*.

Order Sarcosporidia—*Sarcocystis miescheriana*.

Class Mastigophora—

Subclass Flagellata—*Trypanosoma* and *Trichomonas*.

Class Sarcodina—

Subclass Rhizopoda—The ameba of dysentery, *Entamoeba histolytica*.

Class Mycetozoa—

Order Myxomycetes.

This group presents both animal and plant characters.

ALLIED FORMS OF PLANT LIFE:

Algae—

Cyanophyceæ.

Palmaceæ.

Bacteria—

Chlorophyl.

Pleomorphism.

“*Bacterium zophi*.”

Vibrio cholerae.

Bacillus pestis.

The bacterial cell:

Its membranes—

Capsule.

Nucleus.

Granules.

Methods of reproduction—

Division.

Spore formation.

CLASSIFICATION OF SCHIZOMYCETES—

1. According to some characteristic feature:

- a.* Chromogenic—production of color.
- b.* Photogenic—production of light.
- c.* Zymogenic—causing fermentation.
- d.* Saprogenic—causing putrefaction.
- e.* Pyogenic—causing formation of pus.

2. According to morphology:

Cocci—

- a.* Micrococci—spherical.
- b.* Diplococci—spheres in pairs.
- c.* Streptococci—spheres in chains.
- d.* Staphylococci—spheres in clusters.
- e.* Tetrads—spheres in double pairs.
- f.* Sarcina—spheres in bundles.
- h.* Ascococcus—massive colonies with tough, thick, gelatinous envelopes.

Bacilli—

- a.* Leptothrix—filaments of great length.
- b.* Cladotrix—long filaments, pseudo-dichotomy, motile gonidia.
- c.* Streptothrix—branched filaments, mouldy appearance on solid media, aerial hyphae.

Spirilla—

- a.* Vibrio.
- b.* Spirillum.
- c.* Spirocheta. (Probably flagellate animal parasites.)

3. According to motility:

- a.* Nonmotile.
- b.* Motile.
- c.* Brownian motion.

4. According to arrangement of flagella:

- a.* Monotrochal—a single flagellum at the end of the cell.
- b.* Amphitrochal—a single flagellum at each pole.
- c.* Lephotrochal—a cluster of flagella at one pole.
- d.* Peritrochal—a varying number of flagella surrounding the body of the bacterium.

5. According to relation of spores:

- 1. Nonspore bearing.
- 2. Spore bearing—
 - a.* Endospores.
 - b.* Arthrospores.

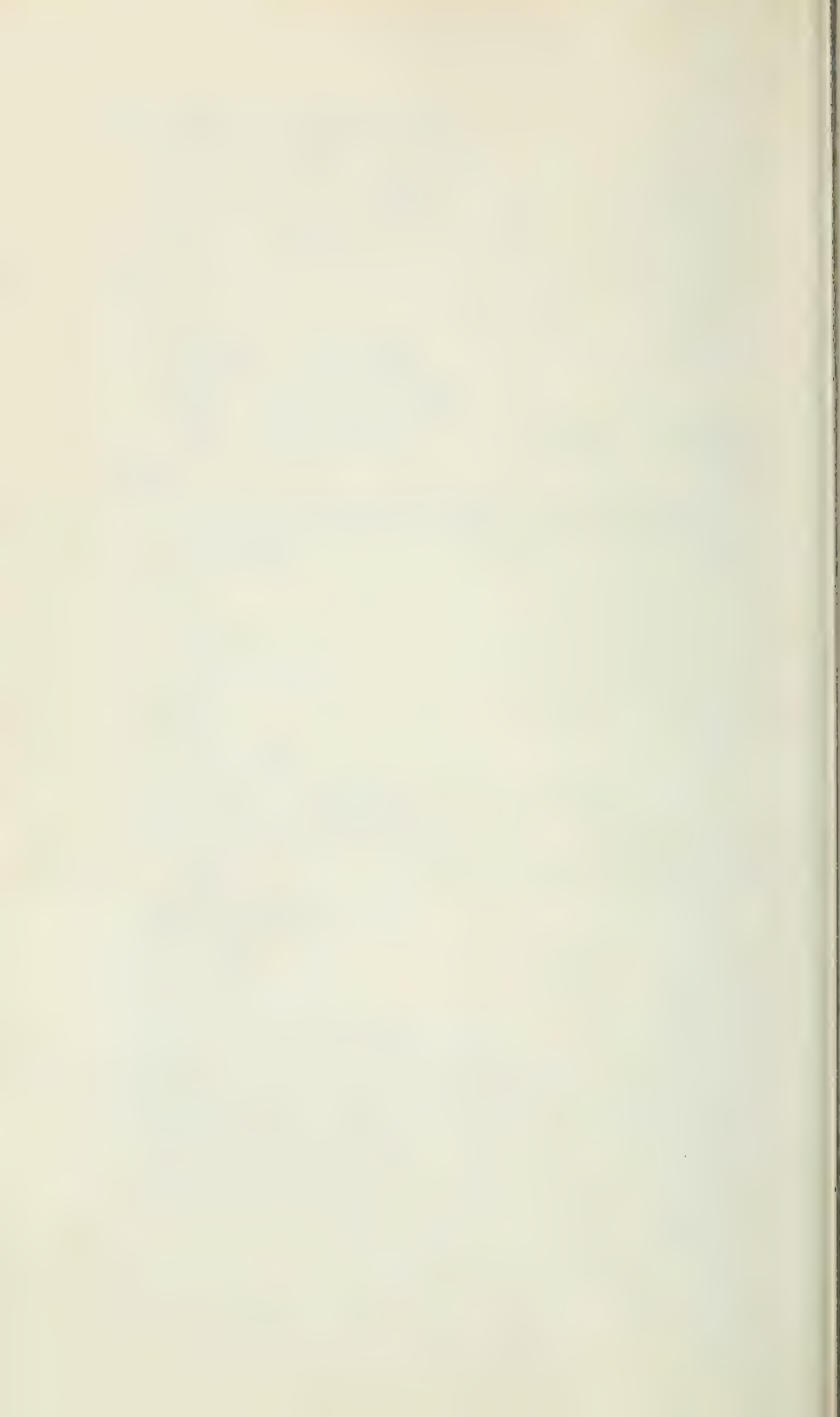
6. According to relations of host:

- a.* Parasitic; grow and develop in living host.
- b.* Saprophytic; grow and develop upon dead organic matter.
- c.* Pathogenic; induce disease.
- d.* Nonpathogenic; harmless; may be parasitic or saprophytic.

7. According to relations to oxygen:

- a.* Aerobic.
- b.* Anaerobic.

Facultative and obligate.



MAKING PLATES, ETC.

1. Koch's method—glass plates.
2. Esmarch's roll tubes.
3. Slants of agar and gelatin in test tubes.
4. Petri dishes—
 - Streaking on surface with platinum wire.
 - Daubing with swabs on surface.
 - Mixing while fluid.

OBTAINING PURE CULTURES—

1. By plate method on solid media.
2. By dilution in liquid media.
3. By temperature.
4. Inoculation into animals.
5. Negative plates.
6. Special methods.

OBSERVE GROWTH AND MULTIPLICATION OF BACTERIA IN CELL SLIDE—AGAR METHOD:

1. Division of bacilli.
2. Division of cocci.
3. Sporulation.

STUDY OF BROWNIAN MOVEMENT WITH—

India ink and other substances in hanging drop.

COUNTING COLONIES, i. e., number of bacteria.

1. Petri dishes—
 - Aim to have not over 200 colonies on the plate.
 - Count with a lens $\times 5$ D.
 - Wolffügel's counting apparatus.
 - H. W. Jeffer's plate.
2. Esmarch's roll tubes.
3. By dilution in liquid media.

THE PRINCIPLES, CHEMISTRY, AND PRACTICE OF STAINING—

A. Animal stains:

Carmines—

- a.* Acid.
- b.* Alcoholic.
- c.* Alum.
- d.* Borax.

B. Vegetable stains:

Hematoxylin—

- a.* Delafield's hematoxylin.
- b.* Alum hematoxylin.
- c.* Hemalum (Meyer).
- d.* Hematoxylin and eosin.
- e.* Acid hematoxylin

C. Anilin stains:

1. Acid stains—

- a.* Eosin.
- b.* Acid fuchsin.
- c.* Orange G.
- d.* Soudan III.
- e.* Picric acid.

2. Basic stains—

- a.* Methylene blue (Löffler's solution).
- b.* Thionin.
- c.* Fuchsin (Carbol-fuchsin).
- d.* Gentian violet (Ehrlich's aniline water).
- e.* Methyl violet.
- f.* Bleu d'argent.

D. Special stains—

a. The polychrome blues—

Romanowsky's.

Wright's.

Goldhorn's.

Jenner's.

b. Weigert's fibrin stain.*c.* Mallory's connective tissue stain.

Acid fuchsin.

Phospho-molybdic acid.

Acid fuchsin.

Anilin blue.

E. Gram's method and solution.

F. Decolorization and differentiation:

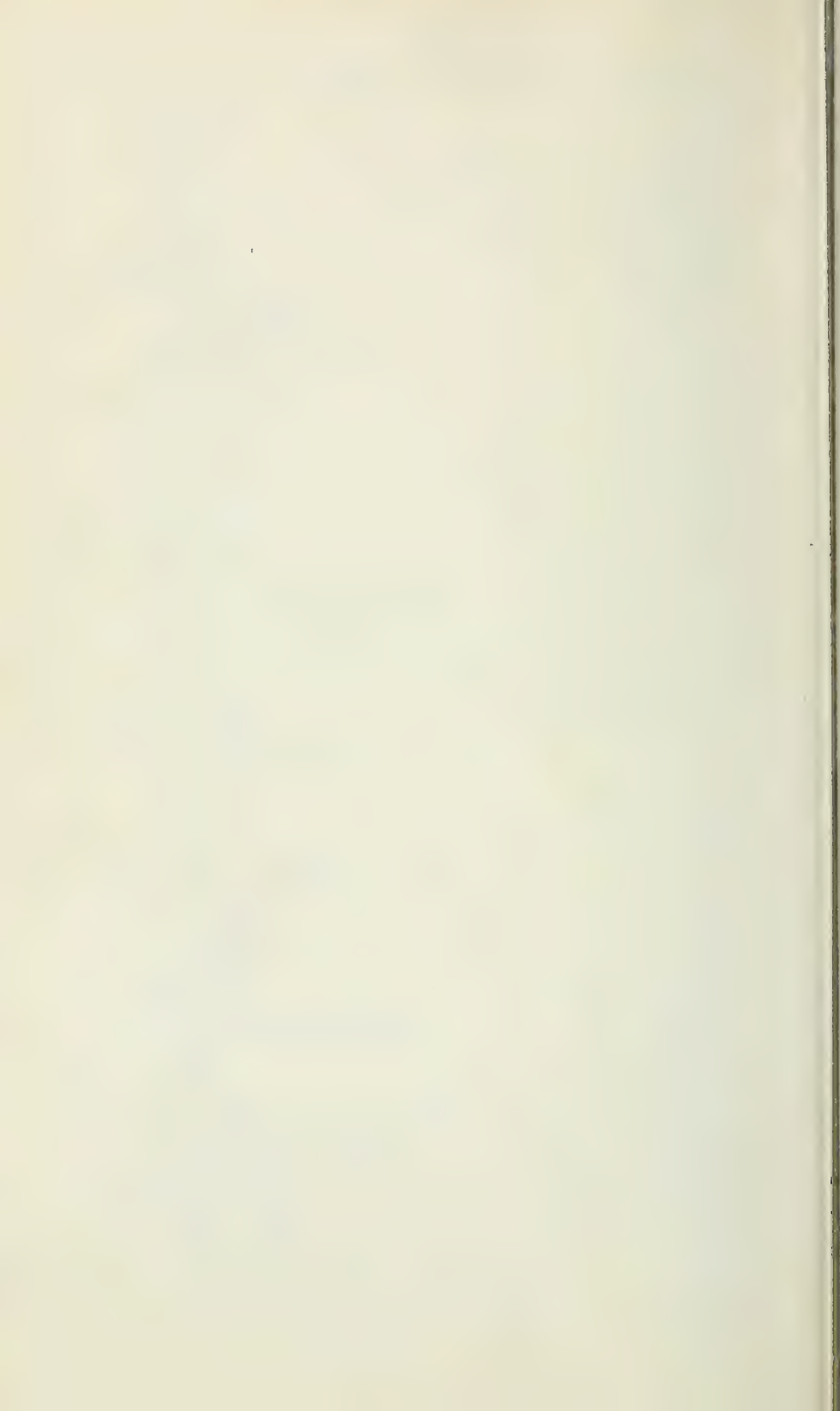
- a.* Water.
- b.* Alcohol.
- c.* Anilin oil.
- d.* Hydrochlorate of anilin, 2 per cent.
- e.* Acids—organic and mineral.

G. Staining of spores:

Möller's method.

H. Staining of flagella:

- a.* Löffler's method.
- b.* Victoria blue.
- c.* Von Ermengem's method.



PRINCIPLES, CARE, AND USE OF INSTRUMENTS AND APPARATUS IN
THE HYGENIC LABORATORY.

- a.* Centrifuge.
- b.* Crematory.
- c.* Photographic apparatus.
- d.* Cleaning glassware.
- e.* Microscopes.
- f.* Paraffin bath.
- g.* Analytical balances.
- h.* Microtomes.
- i.* Thermostats.
- j.* Thermo-regulators; electric, mercurial, metallic.
- k.* Vacuum pumps.
- l.* Blowpipe.
- m.* Camera lucida.
- n.* Spectroscope.
- o.* X-ray tubes and induction coil.
- p.* Autoclaves.
- q.* Dry wall sterilizer.
- r.* Arnold steam sterilizer.
- s.* Blood serum sterilizer.
- t.* Refrigerating plant, ice box, low temperature incubator, drinking water.
- u.* Sterilization of instruments, glassware, etc.
- v.* Sharpening and care of cutting instruments.

OPTIC PRINCIPLES INVOLVED IN MICROSCOPY—

1. Lenses:

- a.* Plano-convex.
- b.* Biconvex.
- c.* Concave.
- d.* Biconcave.
- e.* Doublets.
- f.* Triplets.
- g.* Quadruplets.

2. Objectives:

- a.* Achromatics.
- b.* Apochromatics.
- c.* Panchromatics.

3. Oculars:

- a.* Huyghenian.
- b.* Compensation.
- c.* Spectroscopic.
- d.* Micrometer.
- e.* Projection.

4. Condensers:

a. Simple—

- 1. Biconvex.
- 2. Plano-convex.

b. Abbe—

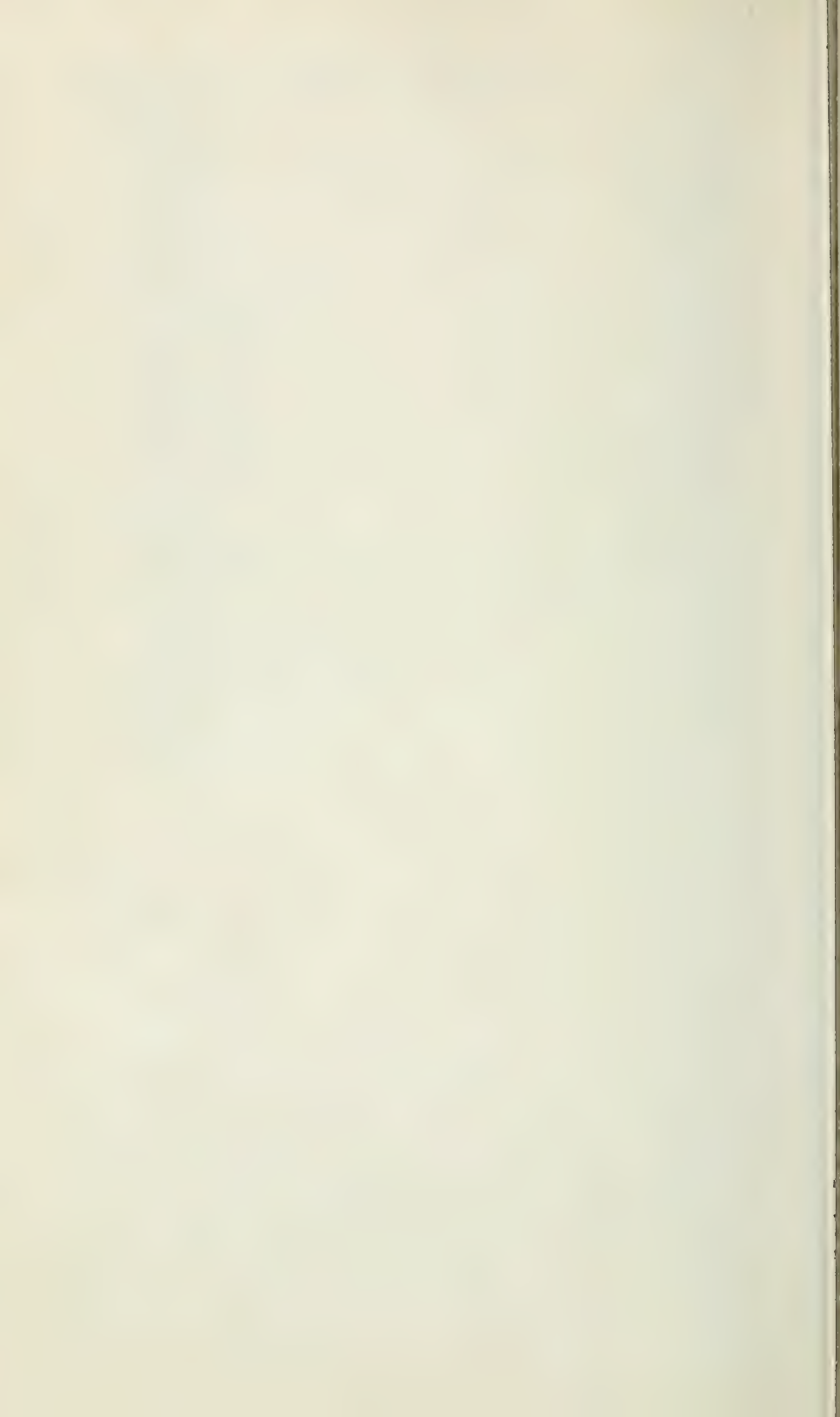
Numerical aperature 1.20.

Numerical aperature 1.40.

5. Microphotography and projection.

6. Micrometers:

- a.* Stage.
- b.* Ocular.
- c.* Projection.



MEASURING MICROSCOPIC OBJECTS—

1. Eye-piece micrometer.
2. Stage micrometer.
3. Photographic method.

GLASS BLOWING.

1. The blowpipe.
2. Pipettes.
3. Bulbs.
4. Welding.
5. Sealing and opening glass containers.
6. Making test tubes.
7. Making perforated tubes for collodium sacks.

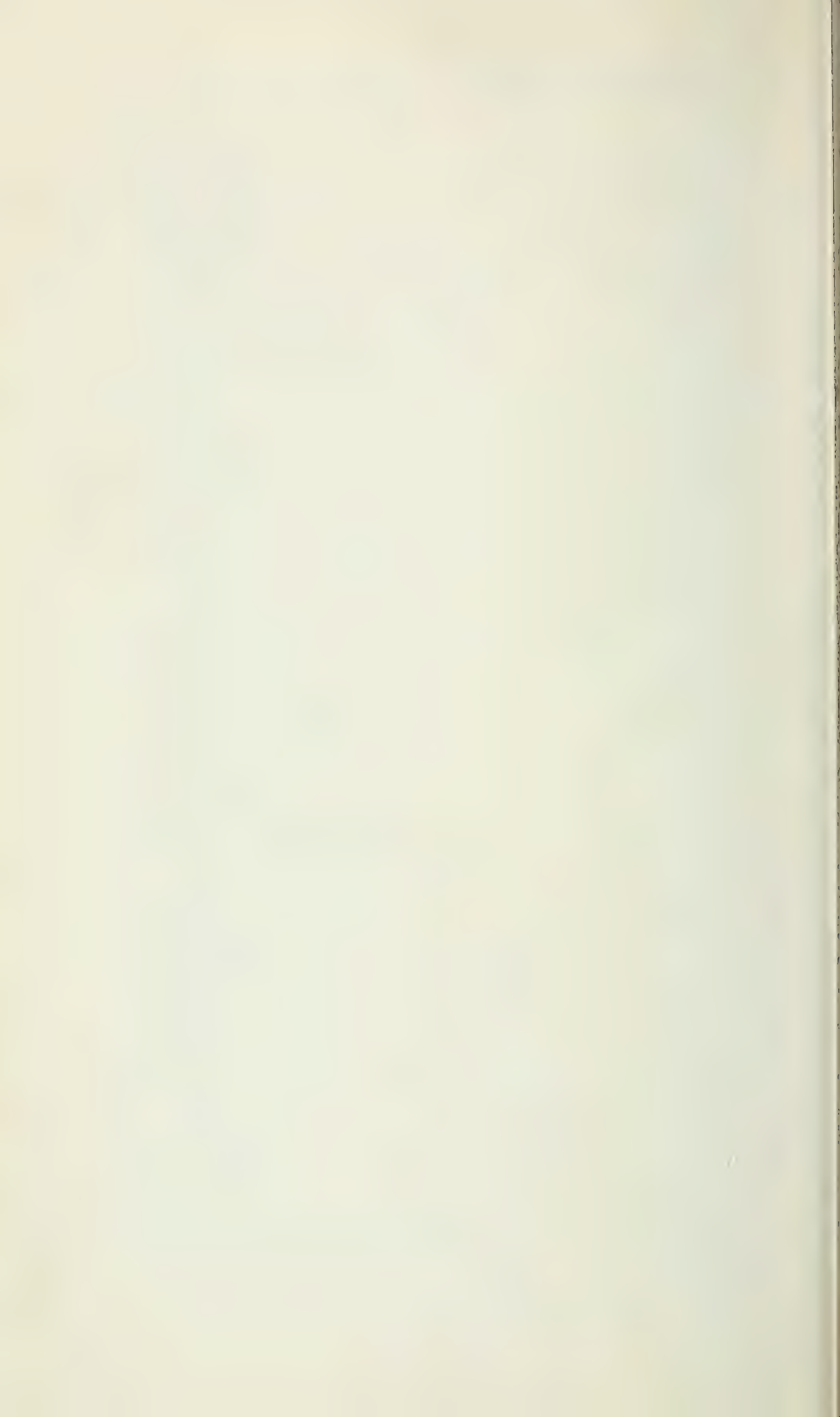
FOLDING PAPER FILTERS.

PREPARING BACTERIOLOGIC FILTERS (PRINCIPLES AND PRACTICE)—

1. Kaolin.
2. Diatomaceous earth.
3. Asbestos.
4. Sand filtration.

PREPARATION AND MOUNTING OF HISTOLOGIC SPECIMENS—

1. Fixation:
 - a.* Acetic-bichlorid of mercury.
 - b.* Müller's fluid.
 - c.* Chrom-acetic acid.
 - d.* Flemming's solution.
 - e.* Formaldehyd.
 - f.* Absolute alcohol.
2. Dehydration:
 - a.* Alcohol 70 per cent (iodin alcohol if H_2Cl_2).
 - b.* Alcohol 85 per cent.
 - c.* Alcohol 95 per cent.
 - d.* Absolute alcohol, twice.
3. Clearing:
 - a.* Xylol.
 - b.* Chloroform.
 - c.* Turpentine.
 - d.* Oil cloves.
 - e.* Oil bergamot.
 - f.* Oil organum.
4. Infiltration and imbedding:
 - a.* Paraffin.
 - b.* Celloidin.
5. Sectioning:
 - a.* Single sections.
 - b.* Serial sections.
6. Attaching section to slide:
 - a.* Alcohol 80 per cent.
 - b.* Water.
 - c.* Myer's albumen.
 - d.* Gum Arabic.
 - e.* Collodium and clove oil.
7. Removal of imbedding material:
 - a.* Xylol to remove paraffin.
 - b.* Alcohol and water.
8. Staining:
 - a.* Nuclear staining.
 - b.* Protoplasmic.
 - c.* Regressive.
 - d.* Gram's.
 - e.* Bacterial.
 - f.* Special.
9. Dehydration in absolute alcohol, anilin oil.
10. Clearing:
 - a.* Xylol.
 - b.* Turpentine.
 - c.* Oil organum.
 - d.* Oil bergamot.
 - e.* Oil cloves.
 - f.* Chloroform.
11. Mounting in xylol balsam, or gum thus.



THE PARAFFIN BATH AND PARAFFIN IMBEDDING—

- A. Fixing.
- B. Dehydration.
- C. Clearing.
- D. Imbedding in paraffin.
- E. Molding block.
- F. Method of numbering, registering, and storing.
- G. Cutting.
- H. Fixing to slide.
- I. Remove paraffin.
- J. Stain.
- K. Dehydrate.
- L. Clear.
- M. Mount in xylol balsam.

CELLOIDIN IMBEDDING—

Fix.

Dehydrate.

Clear.

Prepare a thin celloidin solution containing 4 per cent celloidin in equal parts of absolute alcohol and ether; preserve celloidin solutions carefully from moisture.

Prepare a saturated solution in the same solvent.

Transfer tissue from absolute alcohol to equal parts of alcohol and ether.

From alcohol and ether to thin celloidin.

From thin celloidin to thick celloidin.

From thick celloidin to paper mold on vulcanite block.

Into 70 per cent alcohol for three days to harden.

Cut section with knife flooded with 80 to 85 per cent alcohol.

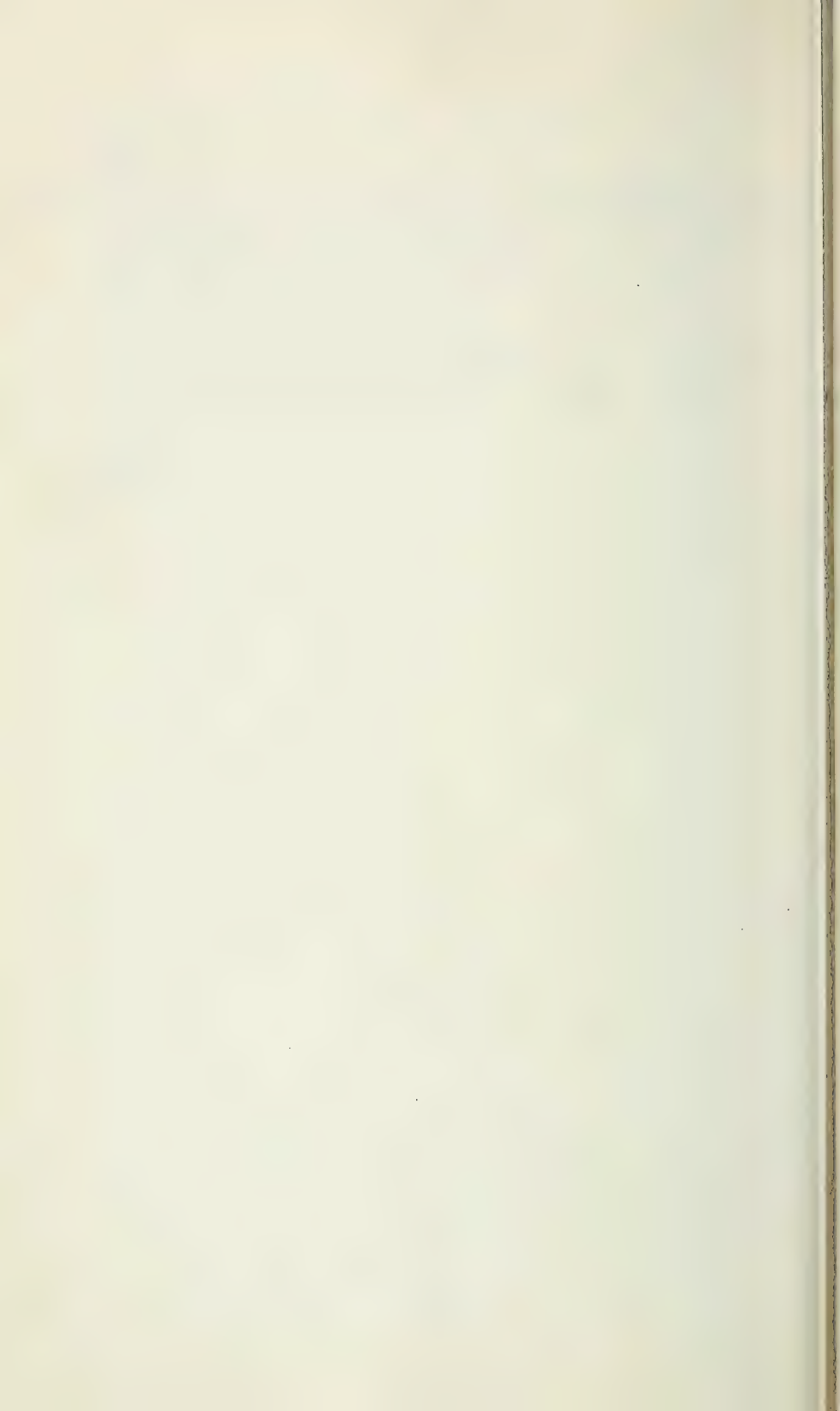
Preserve in 80 to 85 per cent alcohol.

Stain.

Dehydrate.

Clear.

Mount.



METHOD OF MAKING FROZEN SECTIONS. (Wright.)

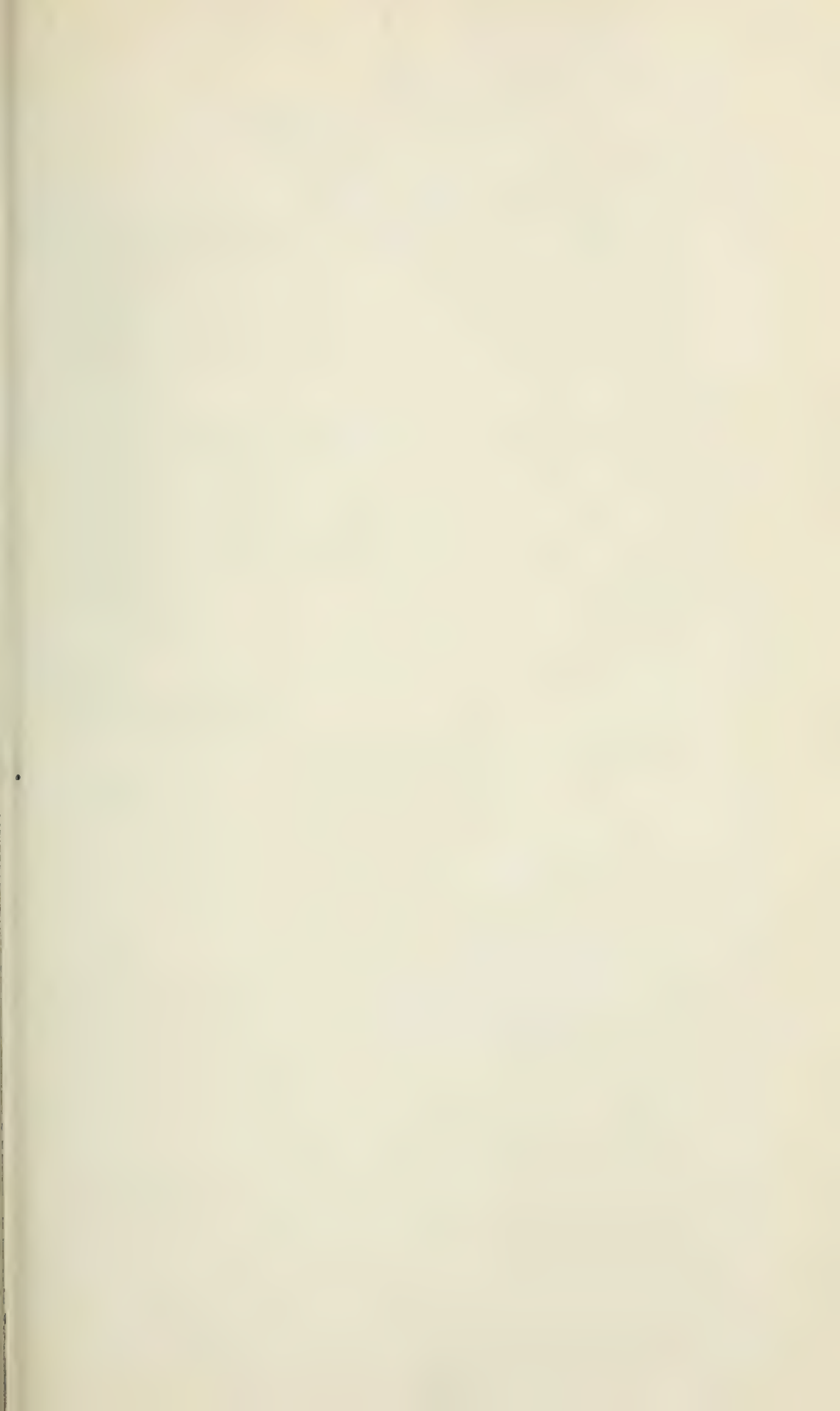
1. Place tissue not over 5 mm. thick in 10 per cent formalin for two or more hours.
2. Wash in water.
3. Freeze with CO₂ or ether.
4. Cut frozen sections.
5. Float sections in normal salt solution and then on slide.
6. Cover section with cigarette paper, then with blotter moistened with 95 per cent alcohol. Press. Remove papers.
7. Cover with absolute alcohol thirty seconds. Drain.
8. Flow over the section and adjacent parts of the slide a thin solution of celloidin in equal parts of absolute alcohol and ether. Drain off immediately. The celloidin should form a coating so thin as to be invisible.
9. Flood the slide with 95 per cent alcohol and then immerse in water. This hardens the film.
10. Stain.
11. Dehydrate.
12. Clear with oil origanum.
13. Mount in Canada balsam.

STAINING TISSUES IN SECTIONS.

1. Hemalum and eosin.
2. Delafield's hematoxylin.
3. Eosin and thionin.
4. Carmine stains.
5. Weigert's fibrin stain.
6. Jenner's stain.
7. Van Giesen for connective tissues.
8. Mallory's connective tissue stains.

STAINING BACTERIA IN SECTIONS.

1. Gram's method.
2. Eosin and thionin.
3. Thionin.
4. Methylene blue.





REVIEW OF HISTOLOGY.

Quiz and practical studies.

EPITHELIAL TISSUES.

Classified according to form, arrangement, or special modification:

A. Classification according to form:

1. Squamous—
Simple (pavement).
Stratified.
2. Polyhedral—
Cuboidal.
Sphenoidal.
Glandular.
3. Columnar.

B. Classification according to arrangement:

1. Simple.
2. Transitional.
3. Stratified.

C. Classification according to special modification:

1. Ciliated.
2. Goblet cells.
3. Pigmented.
4. Prickle cells.

The cell—

Structure.

Functions.

Karyokinesis (onion tips).

ENDOTHELIAL CELLS.

1. Serous.
2. Vascular.

SKELETAL TISSUES (CONNECTIVE).

1. Mucous.
2. Reticular.
3. Fibrous—
 - a.* Alveolar—
 - Fixed cells.
 - Connective tissue cells.
 - Granular.
 - Plasma.
 - Pigment.
 - Wandering cells.
 - b.* Tendons, aponeuroses, etc.
 - c.* Elastic.
4. Adipose.
5. Cartilage—
 - a.* Hyalin.
 - b.* White fibrous.
 - c.* Yellow elastic.
6. Bone.

MUSCULAR TISSUES.

1. Striated.
2. Nonstriated.
3. Cardiac.

NERVOUS TISSUES.

1. Nerve cells.
2. Nerve fibers—
 - a.* Medulated.
 - b.* Nonmedulated.
3. Ganglia.

CIRCULATORY SYSTEM.

1. Arteries.
2. Veins.
3. Capillaries.
4. Heart.
5. Blood—
 - a.* Red cells.
 - b.* White cells.
 - c.* Plaques.

LYMPHATIC SYSTEM AND DUCTLESS GLANDS.

1. Lymph vessels.
2. Lymph glands.
3. Spleen.
4. Thymus.
5. Hemolymph glands.
6. Serous membranes.
7. Synovial membranes.
8. Thyroid.

MUCOUS MEMBRANES AND GLANDS.

1. Mucous membranes.
2. Glands—
 - a.* Mucous.
 - b.* Serous.



DIGESTIVE TRACT.

1. Sublingual gland.
2. Submaxillary gland.
3. Tongue (papillæ).
4. Tonsils.
5. Esophagus.
6. Stomach (glands).
7. Intestines—
 - a.* Villi.
 - b.* Glands.
 - a.* Lieberkühn's.
 - b.* Brunner's.
 - c.* Solitary.
 - d.* Pylers' patches.
8. Liver.
9. Gall bladder.
10. Parotid.
11. Pancreas.

URINARY ORGANS.

1. Kidney.
2. Ureter.
8. Bladder.
4. Urethra.

MALE SEXUAL ORGANS.

1. Testicle.
2. Prostate.
3. Penis.

FEMALE SEXUAL ORGANS.

1. Ovary.
2. Uterus.
3. Vagina.
4. Mammary gland.

RESPIRATORY ORGANS.

1. Trachea.
2. Bronchi.
3. Lungs.
4. Pleura.

SKIN AND APPENDAGES.

1. Skin.
2. Hair.
3. Sebaceous glands.
4. Sweat glands.

CENTRAL NERVOUS SYSTEM.

1. Spinal cord.
2. Cerebrum.
3. Medulla.
4. Cerebellum.

Cut, stain, mount, and study sections of the following normal tissues:

Skin.

Tongue.

Tonsil.

Esophagus—

Upper.

Lower.

Stomach—

Pyloric.

Cardiac.

Intestine—

Upper duodenum.

Lower ileum.

Large.

Liver.

Gall bladder.

Parotid.

Sublingual.

Submaxillary.

Pancreas.

Spleen.

Kidney.

Ureter.

Bladder.

Penis.

Testicle.

Prostate.

Ovary.

Uterus.

Vagina.

Mammary gland.

Voluntary muscle.

Tendon.

Heart.

Artery and vein.

Lymph gland.

Epiglottis.

Trachea.

Lung.

Thyroid.

Intravertebral disc.

Sciatic nerve.

Spinal cord.

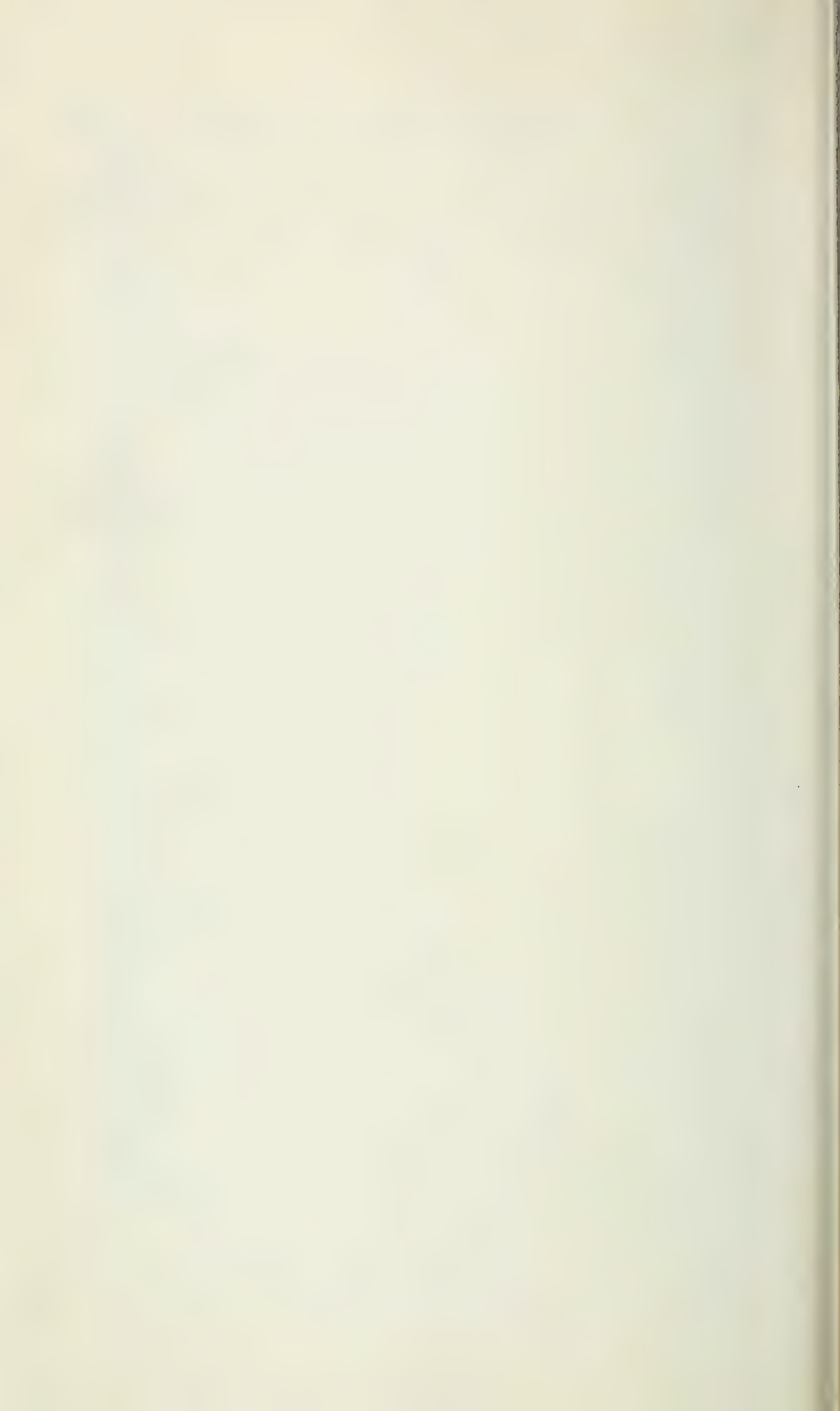
Cerebellum.

Cerebrum.

Medulla.

Embryo.

Umbilical cord.



REVIEW OF PATHOLOGY.

Quiz and practical studies.

GENERAL PATHOLOGY:

Inflammation—

Causes.

Study phenomenon in omentum of frog, etc.

Changes in the vessels.

Exudation.

Changes in the tissues.

Proliferation.

Special forms of inflammation—

Edematous or serous inflammation.

Fibrinous inflammation.

Diphtheritic inflammation. (Coagulation necrosis.)

Croupous inflammation.

Suppurative (abscess) inflammation.

Catarrhal inflammation.

Parenchymatous inflammation.

Productive (interstitial) inflammation.

Hemorrhagic inflammation.

Necrotic or gangrenous inflammation.

Resolution after inflammation.

Regeneration.

Degenerations and infiltrations:

Atrophy.

Cloudy swelling.

Fatty infiltration.

The albuminoid degenerations:

Hyalin.

Mucoid.

Colloid.

Amyloid.

Glycogenic infiltration.

Dropsical infiltration.

Calcification.

Ossification.

Uratic infiltration.

Pigmentation.

Necrosis.

Coagulation necrosis.

Liquefaction necrosis.

Caseation.

Fat necrosis.

Gangrene.

STUDY OF TUMORS.

CAUSE:

External irritation. (Virchow.)

Defective development—embryonal rests. (Cohnheim.)

Infectious character—parasitic theory. Cell inclusions.

Constitutional discrasia.

Loss of compensation between cellular destruction and proliferation.

CLASSIFICATION:

Histogenetic—based on structure.

Embryologic—based on embryologic derivation of tissue forming the tumor.

Clinical—benign, malignant.

METASTASIS.

Cut sections and study the following, which will be found in the laboratory collection:

1. Myoma.
2. Neuroma.
3. Angioma:
 - a. Simple.
 - b. Cavernous.
4. Lymphangioma:
 - a. Simple.
 - b. Cavernous.
5. Fibroma.

Soft fibroma.

Hard fibroma.

Intracanalicular fibroma—of breast.
6. Myxoma.
7. Lipoma.
8. Chondroma.
9. Osteoma.
10. Glioma.
11. Sarcoma:
 - a. Round celled.
 - b. Lympho-sarcoma.
 - c. Alveolar.
 - d. Spindle celled.
 - e. Melano-sarcoma.
 - f. Osteoid.
 - g. Psammoma.
 - h. Myeloid.
 - i. Angiosarcoma.
 - j. Endothelioma.
12. Papilloma.
13. Adenoma.
14. Carcinoma:
 - a. Acinous.
 - b. Epithelioma.
15. Cystoma.
16. Hypernephroma.



SPECIAL PATHOLOGY.

A brief review of the more important lesions.

Cut, mount, stain, and study the following specimens, which will be found in the laboratory collection:

Liver—

- Parenchymatous degeneration.
- Hyalin degeneration.
- Fatty degeneration.
- Spleno-myelogenous leukemia.
- Amebic abscess wall.
- Yellow fever liver.
- Malarial liver.

Kidney—

- Parenchymatous degeneration.
- Amyloid kidney.
- Infected infarct.
- Miliary tuberculosis.
- Large red kidney.
- Large white kidney.
- Granular and contracted kidney.
- Spleno-myelogenous leukemia.
- Hydronephrosis.
- Yellow fever kidney.
- Malarial kidney.

Lungs—

- Chronic passive congestion.
- Croupous pneumonia, red hepatization.
- Croupous pneumonia, gray hepatization.
- Catarrhal pneumonia.
- Bronchiectasis.
- Emphysema.
- Unresolved pneumonia.
- Gumma of lung.

Gastro-intestinal canal—

- Acute catarrhal gastritis.
- Stomach—yellow fever.
- Acute colitis.
- Acute enteritis.
- Follicular enteritis.
- Diphtheritic enteritis.
- Infiltrated Peyer's patches.
- Typhoid ulcer—ileum.
- Cicatrized Peyer's patches.

Circulatory system—

- Arteriosclerosis.
- Aneurismal wall, with thrombus.
- Vessels in yellow fever.

Cut, mount, stain, and study the following specimens, which will be found in the laboratory collection—Continued.

Lymphatic system—

Hyalin degeneration—lymph gland.

Tuberculosis—adenitis.

Primary lymphatic sarcoma.

Lymphatic leukemia.

Typhoid spleen.

Amyloid spleen.

Hodgkins's disease—enlarged glands.

Mucous membranes—

Diphtheritic inflammation, trachea.

Serous surfaces—

Acute fibrinous peritonitis.

Acute pericarditis.

Chronic endocarditis.

Brain and spinal cord—

Spinal cord—cerebrospinal meningitis, diplococcal.

Spinal cord—cerebrospinal meningitis, epidemic.

External pachymeningitis.

Acute meningitis.

Gumma of meninges.

Tuberculous meningitis.

Posterior sclerosis.

Syphilis—

Gumma.

Tertiary lesions—larynx.

Leprosy—

Nerve lesion.

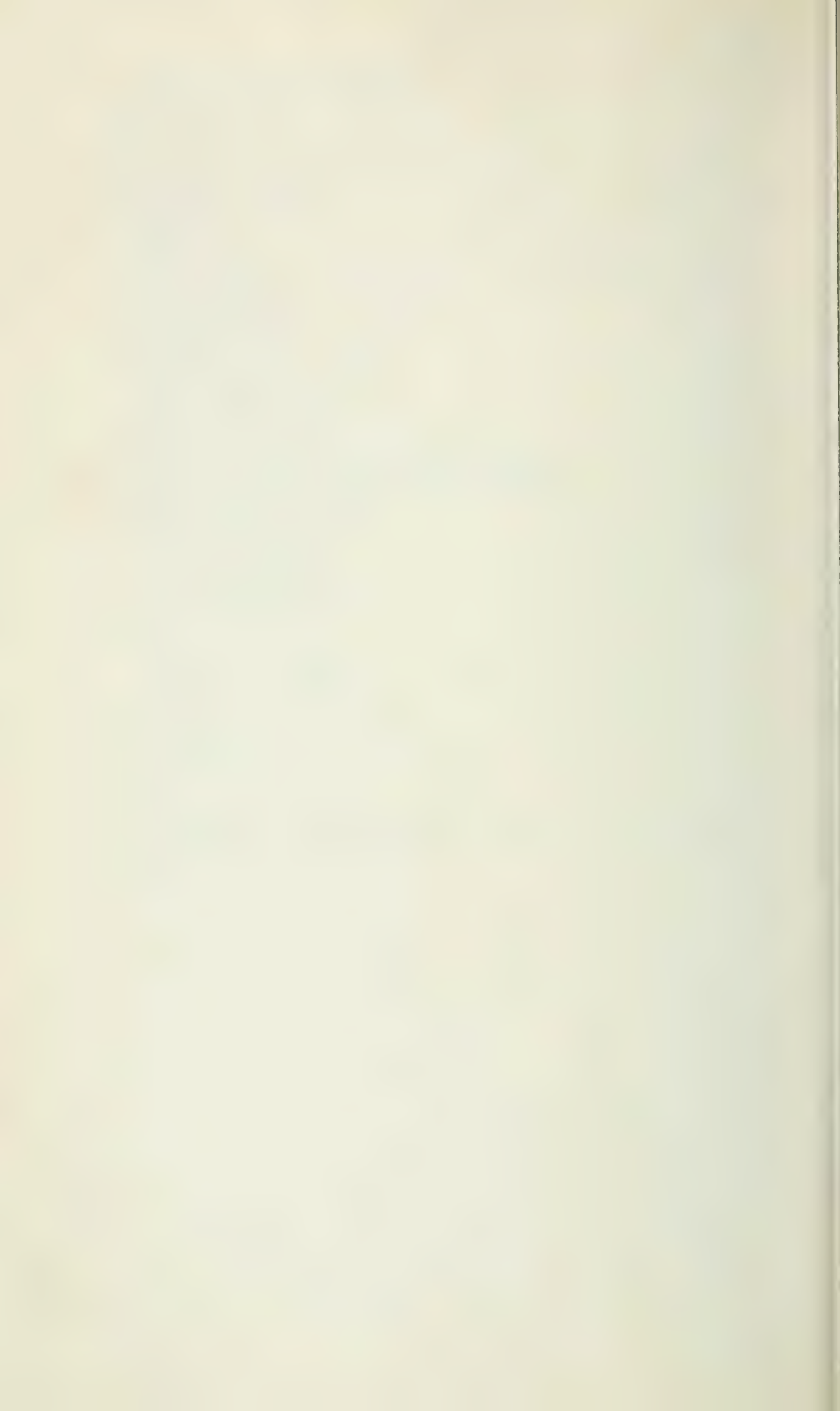
Skin leproma.

Actinomycosis—

Lung.

Tongue.

Other pathologic processes are studied from time to time as they are received for diagnosis.



ANIMAL INOCULATIONS—

1. Subcutaneous method:
 - a. Liquids.
 - b. Solids.
2. Intravenous method.
3. Inoculation into lymphatic system.
4. Inoculation into serous cavities:
 - a. Peritoneum.
 - b. Pleural cavity.
 - c. Subdural space.
5. Inoculation into anterior chamber of eye.

OBSERVATION OF ANIMALS AFTER INOCULATION—

1. Temperature.
2. Loss of weight.
3. Peculiar position in cage.
4. Loss of appetite.
5. Condition of coat.
6. Condition of secretions, etc.
7. Pain.
8. Nervous symptoms, etc.

POST-MORTEM EXAMINATION OF ANIMALS—

1. Cultures from the organs.
2. Cultures from the fluids.
3. Preparation and staining of tissues.

INCINERATION OF DEAD ANIMALS AFTER EXAMINATION—

MAKING COLLODIUM SACKS—

Paris method.

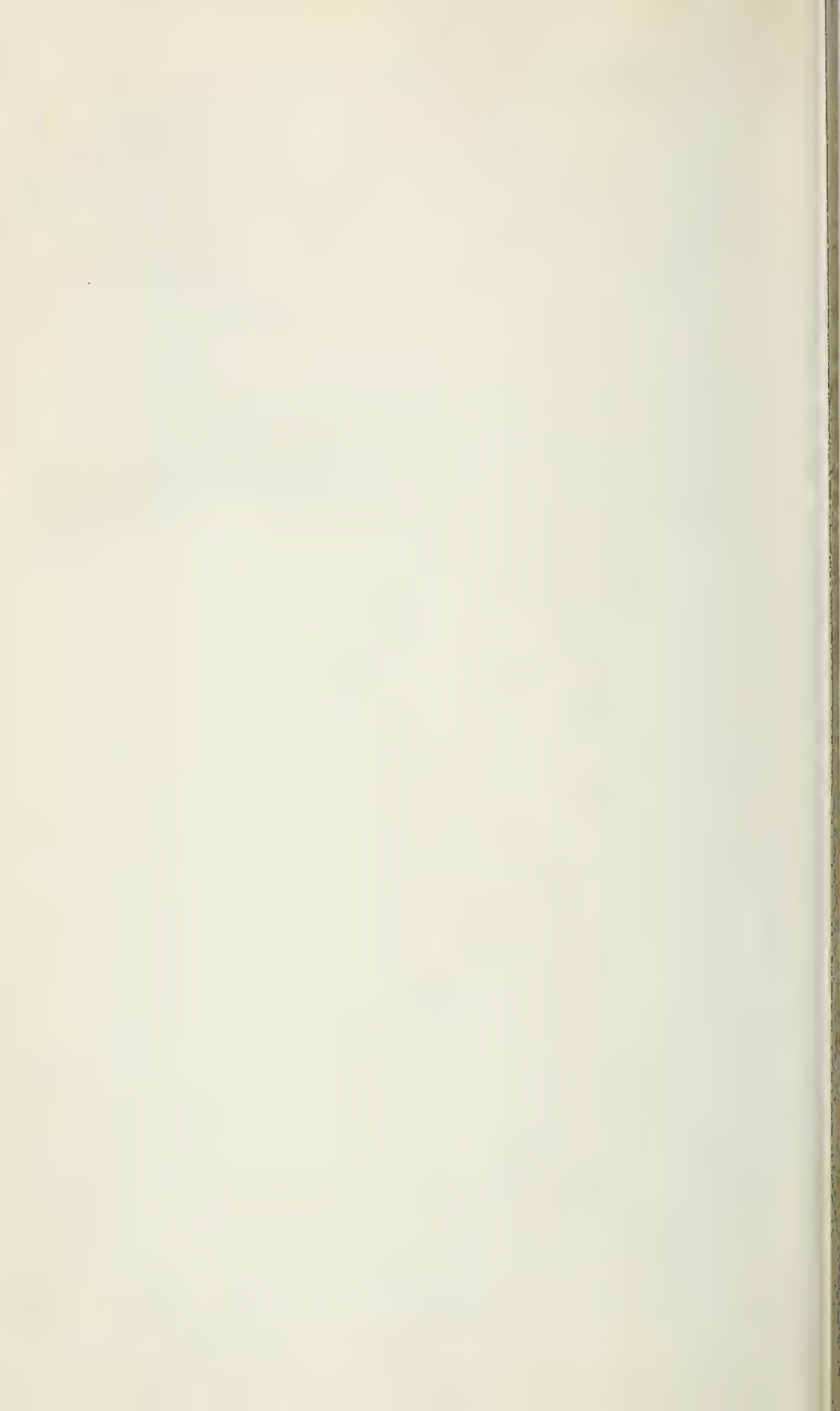
Gelatin capsule method.

With glass support and gelatin (method of Grubbs & Francis).

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BACILLUS COLI Migula, 1900. [*Bacterium coli commune* Escherich.]

- A. Distribution.
- B. Isolate from sewage.
- C. Characteristics:
 - 1. Motility.
 - 2. Gram's method.
 - 3. Nonliquefaction of gelatin.
 - 4. Indol.
 - 5. Gas production.
 - 6. Colonies, etc.
 - 7. Production of acid.
- D. Pathogenesis.
- E. Varieties.
- F. Preparation of its toxin.
- G. Pathogenicity.
- H. Study of blood and organs of infected animals.
- I. Significance in drinking water:
 - 1. Isolation from drinking water.
 - 2. Counting number of colon organisms in a cubic centimeter of water.
- J. Viability.



BACILLUS ANTHRACIS Koch, 1876.

- A. History.
- B. Distribution.
- C. Morphology.
 - 1. Involution forms.
 - 2. Asporogenic form.
- D. Staining.
- E. Cultural characteristics.
- F. Spores:
 - 1. Formation—
 - Relative to oxygen.
 - Relative to nutrient media.
 - Relative to temperature.
 - 2. Development into bacteria.
- G. Pathogenesis (mouse, guinea pig, and rabbit).
 - a. Pneumonic.
 - b. Hemorrhagic.
 - c. Local.
- H. Microscopic examination of liver, blood, spleen, lungs, and other organs.
- I. Vaccination:
 - First vaccine—kills mice, not guinea pigs or rabbits.
 - Second vaccine—kills mice and guinea pigs, not rabbits.
 - Third vaccine—kills mice and guinea pigs and some rabbits.
- J. Disposal of anthrax carcasses:
 - a. Burial, isolated districts.
 - b. Burning.
 - c. Sulphuric acid.
 - d. Boiling.
- K. Human anthrax:
 - a. Malignant pustule.
 - b. Wool sorter's disease.
 - c. Intestinal form.
- L. Viability.
- M. Disinfection for anthrax.

BACTERIUM DIPHTHERIÆ (Löffler) Migula. [*Klebs-Löffler Bacillus.*]

- A. History.
- B. Morphology—relation to clinical types.
- C. Staining:
 - 1. Löffler.
 - 2. Neisser.
 - 3. Roux.
 - 4. Weigert's fibrin method for tissues.
 - 5. Gram's stain.
- D. Biologic characteristics.
- E. Pathogenesis:
 - 1. Guinea pig.
 - 2. Rabbit.
 - 3. Kitten.
- F. Toxin production.
- G. Antitoxin production:
 - 1. Standardization.
 - 2. Prophylactic use.
 - 3. Curative use.
- H. Obtain tubes and swabs from the health department for diagnosis.
- I. Pseudo-diphtheria bacillus.
- K. Xerosis bacillus.
- L. Viability.
- M. Disinfection for diphtheria.
 - The disease—
 - Symptoms.
 - Diagnosis.
 - Treatment.
 - Prophylaxis.

DUCREY'S BACILLUS—Soft chancre—

Obtain in pure culture.

Diagnosis from smear preparations.

Study morphology—

Cultural characteristics.

Relation to lesions.

MICROCOCCUS MELITENSIS Bruce, 1893. Malta fever.

Morphology.

Motility.

Cultural characteristics.

Occurrence in spleen.

Serum diagnosis—agglutinins.

The disease—

Its geographical distribution.

Diagnosis.

Symptoms.

Treatment.

Prophylaxis.



BACTERIA IN INFLAMMATION AND SUPPURATION—

Study:

- A. *Micrococcus aureus* (Rosenbach, 1884) Migula, 1900. [*Staphylococcus pyogenes aureus* Rosenbach, 1884.]
- B. *M. pyogenes* (Rosenbach, 1884) Migula, 1900. [*S. pyogenes albus* Rosenbach, 1884.]
- C. *M. citreus* (Passet, 1885) Migula, 1900. [*S. pyogenes citreus* Passet, 1885.]
- D. "*Staphylococcus epidermidis albus* Welch."
- E. *M. gonorrhææ* (Bumh, 1885) Flügge, 1886.
- F. *Streptococcus pyogenes* Rosenbach, 1884.
- G. "*Streptococcus erysipelutis* Rosenbach, 1884.
- H. *Pseudomonas æruginosa* (Schröter, 1872) Migula, 1900. [*Bacterium æruginosum* Schröter, 1872; *Bacillus pyocyaneus* Gessard, 1882.]

Collect pus and inflammatory exudates from various sources, plate out and study bacteria found.

Study pus in smears on slides.

Also suppurating processes induced by—

The typhoid bacillus.

Colon bacillus.

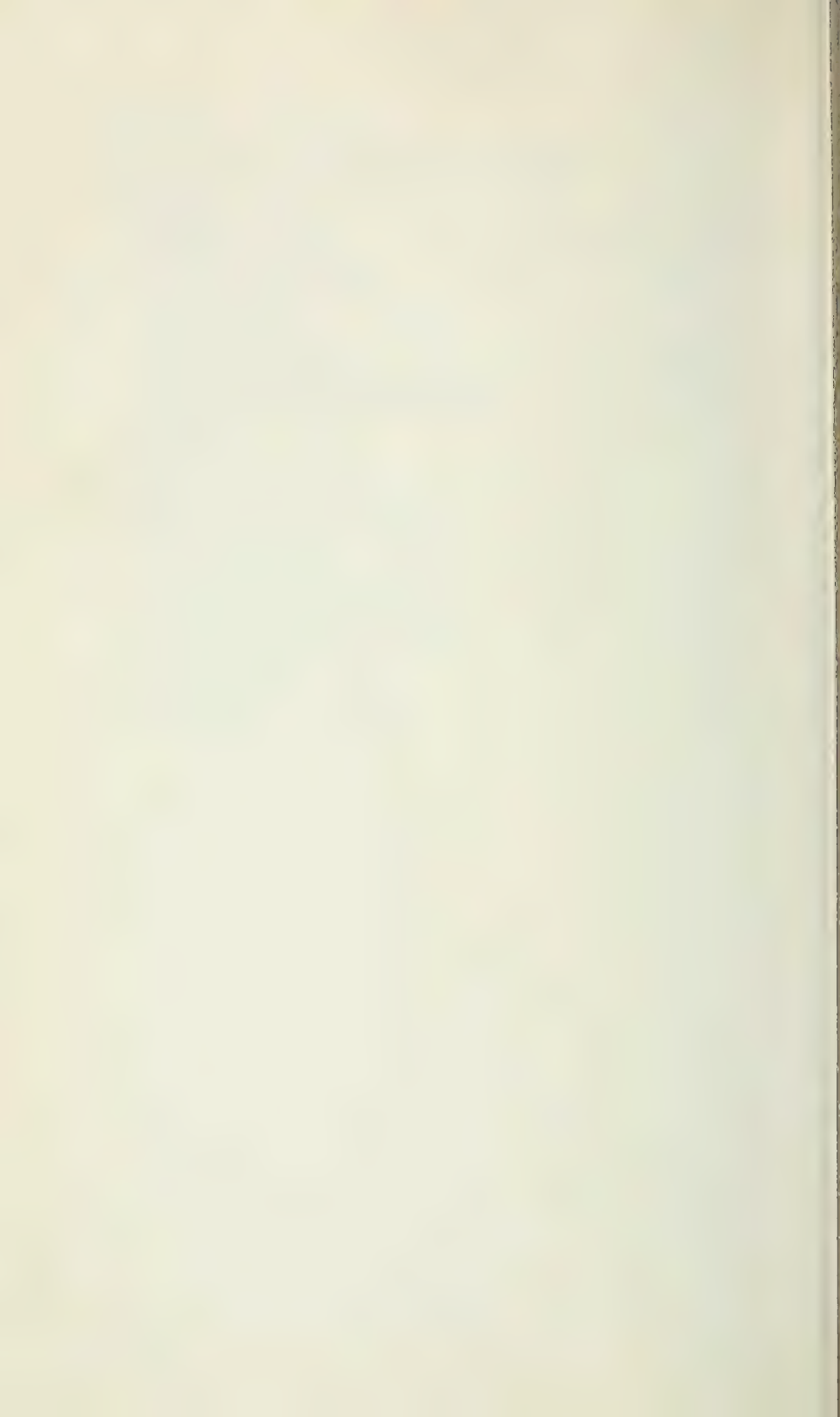
Pneumococcus.

Tubercle bacillus, etc.

THE TYPHOID GROUP—

Compare:

- A. *Bacillus typhosus* Migula, 1900.
 - B. *Bacillus dysenteriae* Shiga, 1898 [not Migula, 1900].
 - C. *Bacillus enteritidis* Gaertner, 1888.
 - D. Paracolon bacillus.
 - E. Paratyphoid bacillus.
 - F. *Bacillus murium* Migula, 1900. [*Bacillus typhi murium*, Löffler, 1893.]
 - G. Bacillus of Danyz's virus.
 - H. *Bacillus psitticosis*.
 - I. *Bacillus icteroides* Sanarelli, 1897.
 - J. *Bacillus acidi lactici*.
 - K. *Bacillus coli* Migula, 1900. [*Bacterium coli commune*, Escherich.]
1. Methods of introduction into the system.
 2. Channels of elimination.
 3. Viability.
 4. Disinfection.
 5. Relation to water supply.
 6. Relation to flies and other insects.
 7. Gruber-Widal reaction with live and dead cultures:
 - a. With hanging drop.
 - b. In pipettes and small test tubes.
 8. Wright's preventive inoculation.
 9. Diagnosis of typhoid fever in early stages.
 - Diazo reaction.
 10. Pathologic lesions.
 11. The management of epidemics.
 12. Prophylaxis.



THE TUBERCLE GROUP—

A. *Bacillus tuberculosis* Koch, 1882:

1. Human. Isolate in pure culture from sputum, or lesion.
2. Bovine.
3. Avian.

Morphology.

Biological characters.

Pathogenesis.

Diagnosis.

Tuberculin—

Production.

Uses.

1. Diagnostic.
2. Therapeutic.

B. Acid proof organisms, resembling *B. tuberculosis*:

1. Möller's grass bacillus. Isolate from timothy.
2. Rabinowitsch's butter bacillus.
3. Karlinsky's nasal secretion organism.
4. Smegma bacillus.

C. *Bacillus lepræ* Hansen.

Cut sections leproma.

D. *Bacillus mallei* (Löffler, 1886) Migula, 1900:

Mallein.

Strauss's method in male guinea pig.

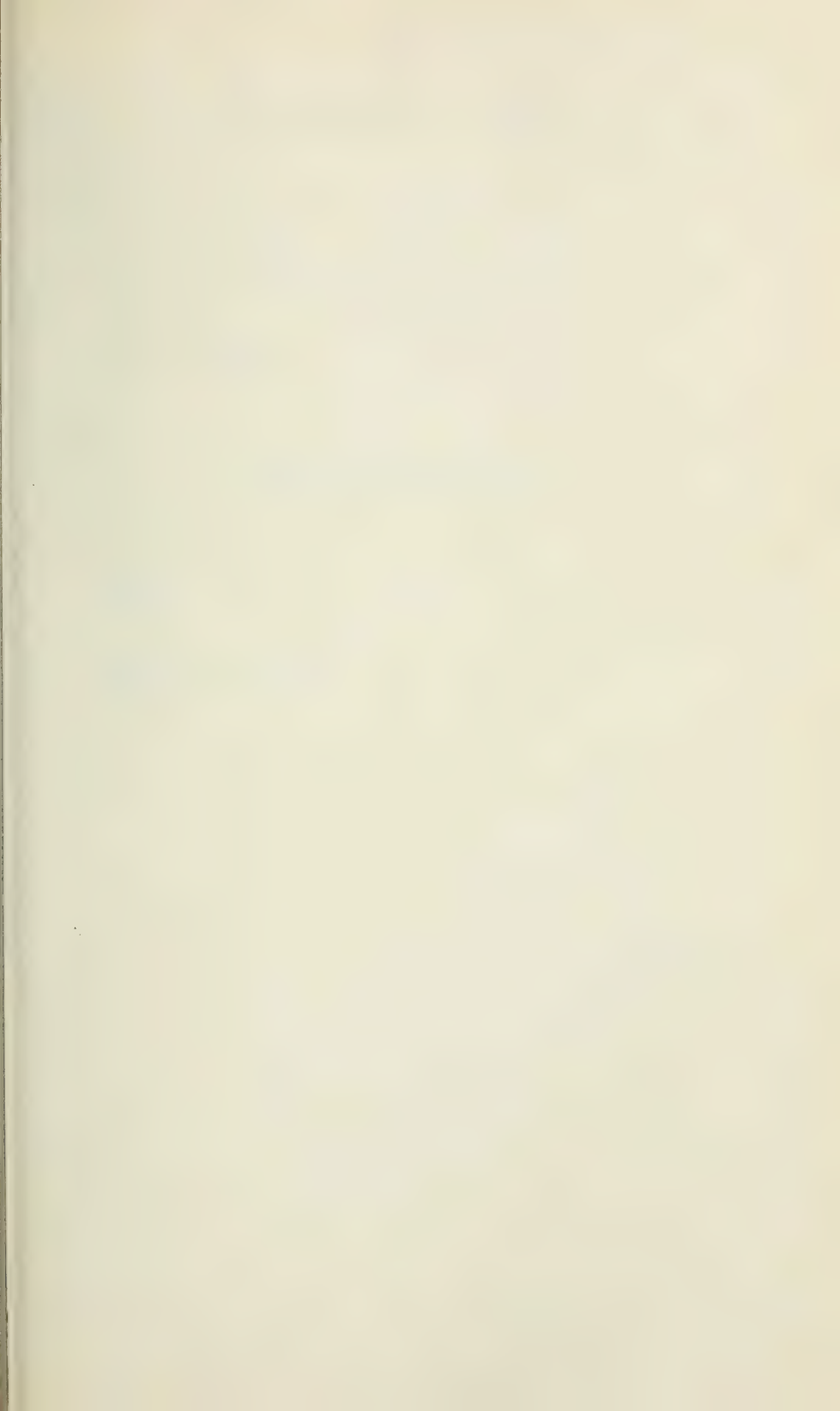
E. Actinomycosis.

F. Mycetoma, madura foot.

G. Pathogenic streptothrices.

THE VIBRIO GROUP—

- A. *Microspira comma* Schröter, 1886. [Koch's comma bacillus of Asiatic cholera.]
- B. *Microspira metshnikovi* (Gamaleia, 1888) Migula, 1900.
- C. *Microspira finkleri* Schröter.
- D. *Vibrio* Denecke.
- E. *Microspira aquatilis* (Günther, 1892) Migula, 1900.
 - Isolation.
 - Diagnosis.
 - Pfeiffer's phenomenon.
 - Widal reaction.
 - Immunity.
 - Haffkine's prophylactic.
 - Viability.
 - Disinfection for cholera.
 - Methods of introduction into system.
 - Channels of elimination.
 - Relation to water supply.
 - Relation to flies and other insects.
 - Quarantine regulations relating to cholera.
 - The management of isolated cases.
 - The control of epidemics.
 - Prophylaxis.





BACILLUS PESTIS Kitasato & Yersin, 1894.

A. Study—morphology, staining, and cultural characteristics:

Viability.

Channels of entrance.

Channels of elimination.

Pathogenicity—guinea pigs, rabbits, rats, mice.

Diagnosis—Kolle's method:

Yersin serum—

Method of manufacture and standardization.

Prophylactic use.

Curative use.

Haffkine prophylactic—

Methods of manufacture.

Uses.

B. Disinfection.

C. Quarantine.

D. Relation of rats and other mammals to spread of plague.

E. Relation of fleas, flies, and insects to spread of plague.

The disease—

Period of incubation.

Symptoms.

Diagnosis.

Varieties.

Lesions.

Treatment.

Management of epidemics.

Prophylaxis.

THE SEPTICEMIC GROUP—

- A. Mouse septicemia.
- B. Rouget du porc.
- C. Chicken cholera.
- D. Swine plague.
- E. Ferret, duck, buffalo, and other plagues.
- F. *Bacillus pestis* KITASATO & YERSIN, 1894.
- G. *Bacterium pneumoniae* (Weichselbaum, 1886) MIGULA, 1900. [*Diplococcus pneumoniae* Weichselbaum, 1886.]
- H. *Bacterium pneumonicum* Migula, 1900. [*Pneumonicoccus* Friedländer, 1882.]
- I. *Bacterium influenzae* Lehmann & Neumann, 1896.

ANAËROBIC TECHNIQUE—

- A. Kipp's hydrogen apparatus:
 - 1. Mechanics.
 - 2. Chemicals.
- B. Simple hydrogen generators.
- C. Solutions for purifying gas:
 - 1. Silver nitrate for chlorine.
 - 2. Potassium permanganate for oxygen.
 - 3. Lead acetate for sulphides.
- D. Media best suited for anaërobes:
 - 1. Freshly prepared media.
 - 2. Glucose media.
- E. Special methods:
 - 1. Fraenkel's method.
 - 2. Esmarch's method.
 - 3. Liborius's method.
 - 4. Buchner's method.
 - 5. Novy's jars.
 - 6. Wright's method.
 - 7. Pasteur Institute method.
 - 8. Vignal's tubes.
 - 9. Full tubes of bouillon.
 - 10. Deep stabs.
 - 11. Oil method.
 - 12. Smith's apparatus.

ANAËROBES—

A. *Bacillus tetani*, its toxin and antitoxin.

B. *Bacillus edematis* of malignant edema.

C. *Bacillus Chauvvi* Arloing, Cornevin & Thomas, of symptomatic anthrax:

Vaccine—

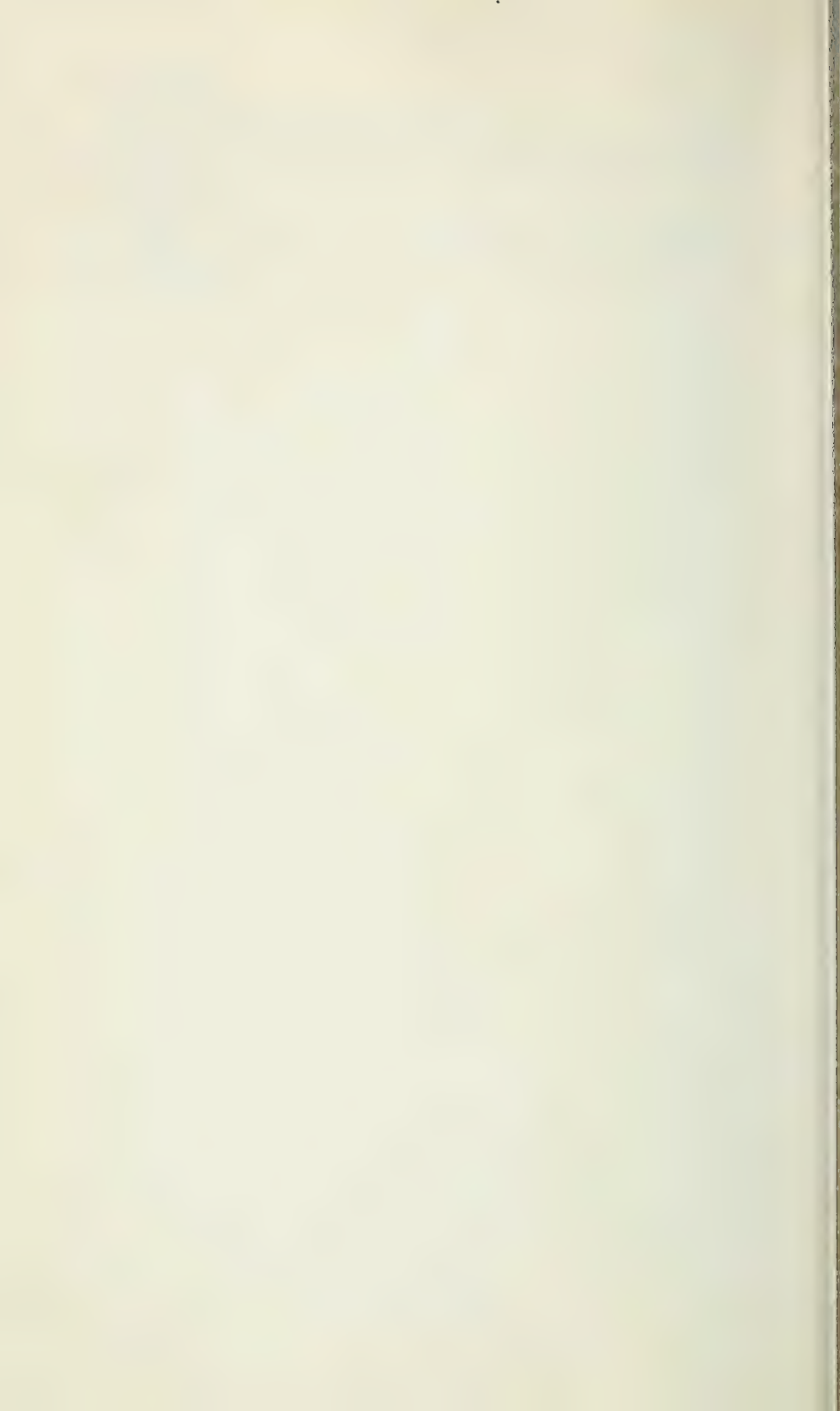
1. Manufacture.

2. Use.

D. *Bacillus welchii* Migula, 1900. [*Bacillus aërogenes capsulatus* Welch & Nuttall, 1892.]

Disinfection for above.





PATHOGENIC MOLDS—

*Ringworm:**Microsporon Audouini* (Gruby).*Trichophyton*—1. *T. endothrix*.2. *T. ectothrix*.

Hair lesions.

Pure cultures.

*Favus:**Achorion Schoenleinii* Remak.

In the hair and scale.

In pure culture.

*Thrush:**Oidium albicans* (see *Saccharomyces albicans*).

YEASTS—

Saccharomyces cerevisiae Meyen (beer yeast) in pure cultures:

Effect on saccharine media.

Budding.

Red yeast—*S. glutinis*.

Black yeast—*S. niger*.

Saccharomyces albicans (Robin) Reess, 1877 [*Oidium albicans* Robin] thrush, in pure culture.

Pathogenic yeasts.

EXAMINATION OF URINE—

Note:

1. Odor.
2. Color.
3. Deposit. Filtration of specimen.
4. Specific gravity.
5. Reaction.
6. Quantity in twenty-four hours.
7. Albumen—

Tests for albumen; quantitative and qualitative:

- a. Heat (phosphates).
- b. Nitric acid, in test tube and in glass.
- c. Ferrocyanid potash; acetic acid.
- d. Picric acid, Esbach's albumenometer.

8. Sugar—

Test for sugar:

- a. Fehling's solution.
- b. Bismuth.
- c. Quantitative estimation with—
Yeast fermentation.
Fehling's solution.
Polariscope.

9. Estimation of urea.
10. Bile, test for.
11. Microscopic examination of sediment for bacteria, casts, crystals, blood, etc.,
Schistosoma hæmatobium (Bilharz, 1852) Weinland, 1858.
12. Test for chlorids.
13. Diazo reaction.
14. Bacteriologic examination of urine.
15. Disinfection of urine.

BACTERIOLOGIC AND MICROSCOPIC EXAMINATION OF FECES—

1. Microscopic:

a. Normal constituents.

b. Intestinal parasites and their eggs—

Ascaris lumbricoides (Linnæus, 1758).*Oxyuris vermicularis* (Linnæus, 1758) Bremser, 1819.*Trichuris trichiura* (Linnæus, 1771).*Agchylostoma duodenale* (Dubini, 1843).*Uncinaria* (*Necator*) *americana* Stiles, 1902.*Tenia saginata* Gœze, 1782.*Tenia solium* Linnæus, 1758.*Hymenolepis nana* (Siebold, 18—).*Dibothriocephalus latus* (Linnæus, 1758.)*Entameba coli* (Loesch, 1875) = *Amœba coli* [nonpathogenic].*Entameba histolytica* Schaudinn, 1902 = *Amœba* of dysentery [pathogenic].

2. Bacteriologic:

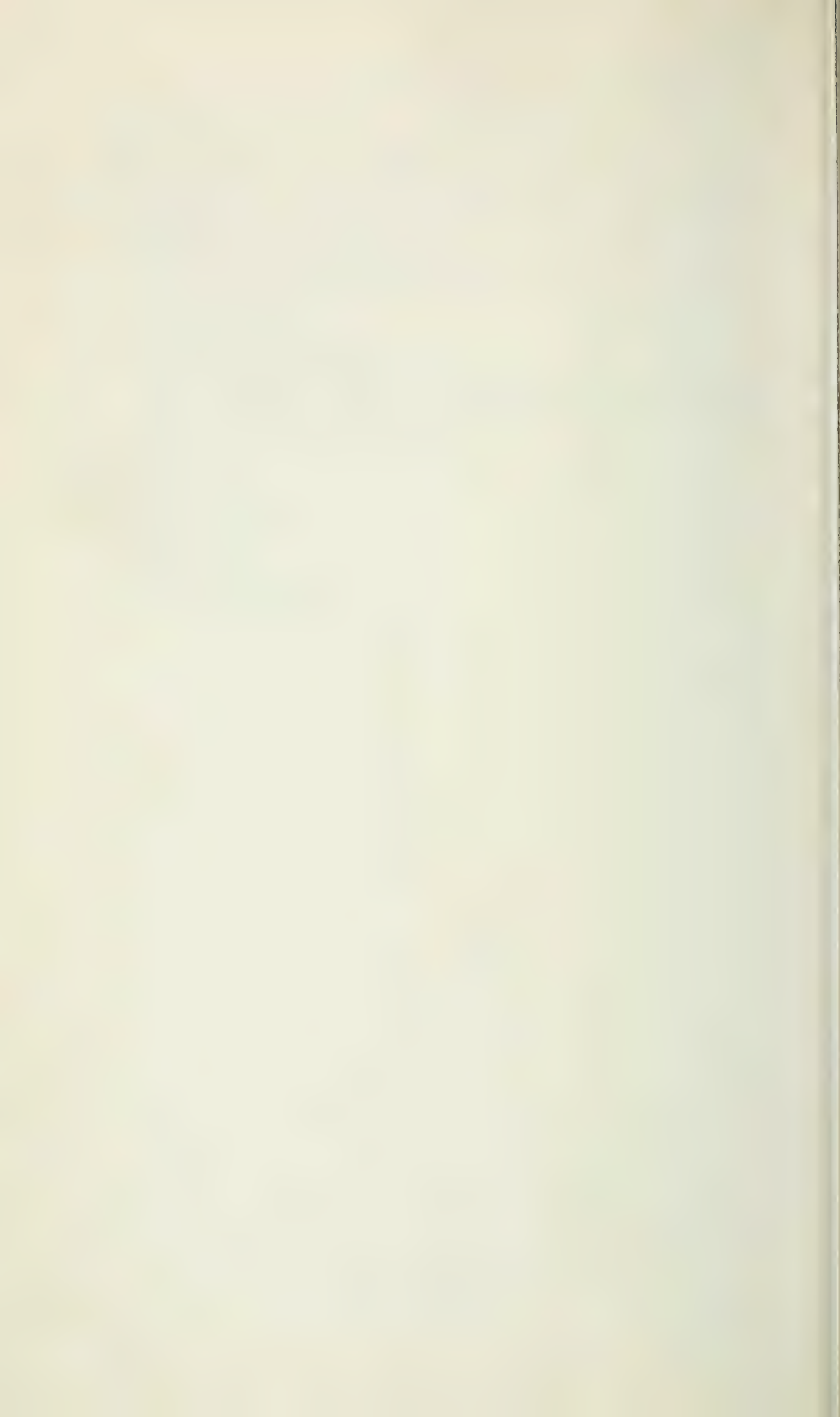
a. Normal flora.

b. Pathogenic—

Bacillus dysenteriae.*Bacillus tuberculosis*.*Bacillus typhosus*.*Microspira comma*.

3. Disinfection of feces.





BACTERIOLOGIC AND MICROSCOPIC EXAMINATION OF—

Sputum, nasal and other mucous secretions:

Tubercle bacilli.

Pneumococci.

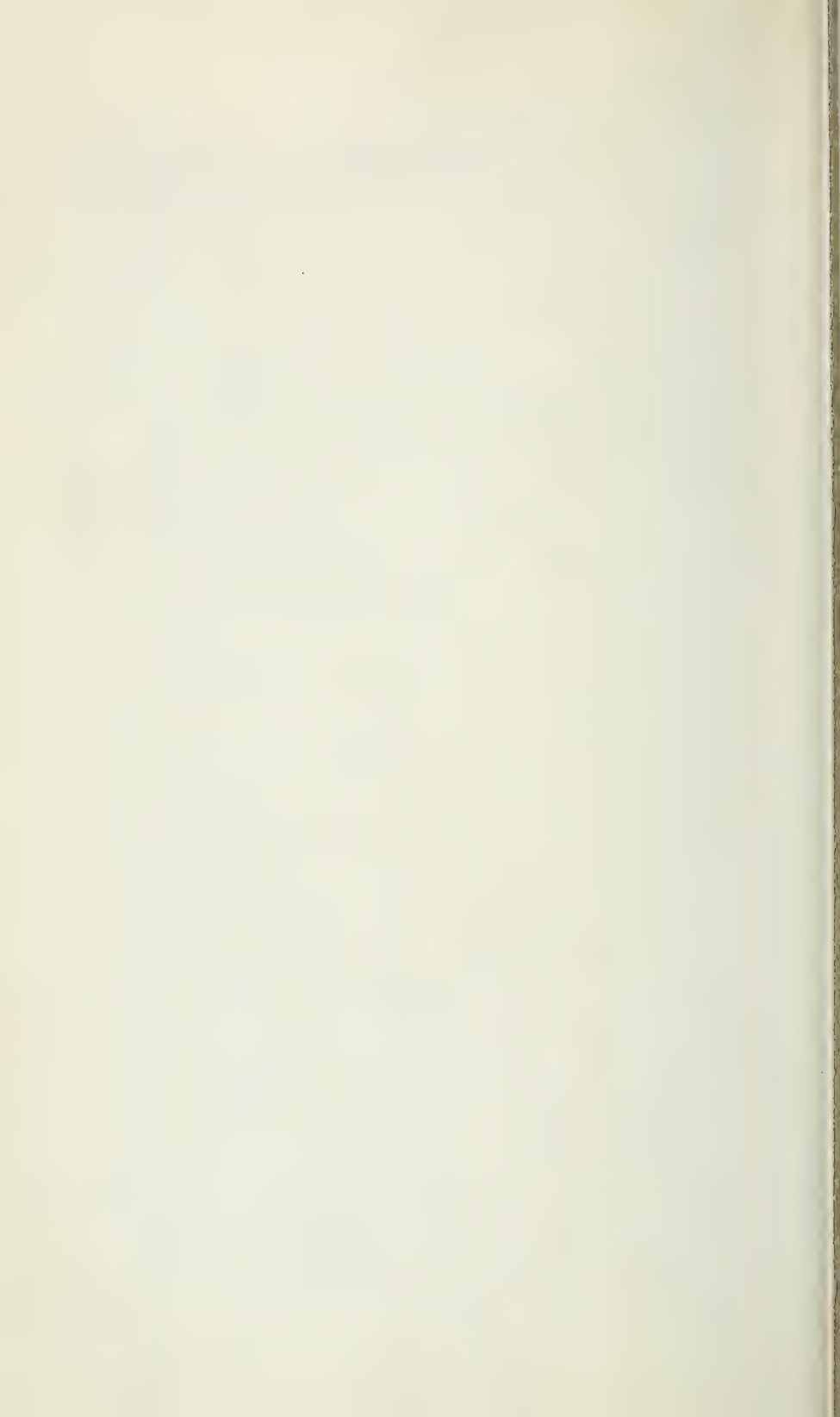
Influenza bacterium.

Disinfection of sputum.

BLOOD.

Technique of:

1. Collecting blood for microscopic examination.
2. Collecting blood for bacteriologic examination—
 - a.* Small amount.
 - b.* Large quantities.
 Of man.
 Of other mammals.
 Of birds.
 Of reptiles.
3. Observe circulation of blood under microscope.
 Mesentery of frog.
4. Estimate alkalinity.
5. Estimate specific gravity of blood with mixture of chloroform and benzol.
6. Examine fresh blood in hanging drop.
7. Examine fresh blood between slide and cover slip.
8. Study of blood films:
 - a.* Method with cover glass.
 - b.* Method with special rod.
 - c.* Method with cigarette paper.
9. Fixation of blood films:
 - a.* Heat, 150° C. for about five minutes.
 - b.* Alcohol and ether.
 - c.* Formalin.
 - d.* Formaldehyd.
 - e.* Acetic acid bichlorid.
 - f.* Wood alcohol.
10. Staining:
 - a.* Ehrlich-Biondi-tri-acid stain.
 - b.* Jenner's stain.
 - c.* Romanowsky's stain.
 - d.* Goldhorn's fluid.
 - e.* Eosin and methylene blue.
 - f.* Thionin and eosin.
 - g.* Wright's.
 - h.* Hematoxylin and eosin.
11. Counting red corpuscles.
 Thoma-Zeiss hemocytometer.
12. Estimating the number of leucocytes:
 - a.* With the Thoma-Zeiss hemocytometer.
 - b.* Comparative count of—
 - a.* Small lymphocytes.
 - b.* Large lymphocytes and transitional forms.
 - c.* Polymorphonuclear neutrophiles.
 - d.* Eosinophiles.
 - e.* Mast cells.
13. Estimating the amount of hemoglobin:
 With—
 - a.* Dare's hemoglobinometer.
 - b.* Oliver's hemoglobinometer.
 - c.* Gower's hemoglobinometer.



BACTERIA IN THE AIR—

1. Number:

Sewer air.

Expired air.

Sea air.

City air.

Country air.

Air in houses, hospitals, etc.—

Relation to the sun.

Relation to habitation.

Relation to winds and traffic.

Relation to altitude.

Pasteur's method.

Miquel's method.

Aeroscopes.

Frankland's method.

Petri's method.

Hesse's method.

Strauss's method.

2. Varieties.

3. Estimation of ammonia in the air.

4. Estimation of carbon dioxid in the air.

BACTERIA IN WATER—

1. Collecting samples.
2. Count number per c. c.:
 - a.* In tap water.
 - b.* In river water.
 - c.* In spring water.
 - d.* In rain water.
 - e.* In ice.
3. Species:
 - Coli communis.
 - Typhoid.
 - Cholera.
4. Organisms in water:
 - a.* Selection.
 - b.* Isolation.
 - c.* Numbers.
5. Estimation of organic matter—
 - a.* Free ammonia.
 - b.* Albuminoid ammonia.
6. Estimation of nitrates and nitrites.
7. Estimation of chlorids.
8. Purification of water:
 - Heat.
 - Filters—
 - a.* Household filters.
 - b.* Field and camp filters.
 - c.* Sand filters—
 - Alum.
 - Hyperoxid of chlorin.
 - Ozone.
 - Permanganate of potash.



BACTERIA IN SOIL.—

1. Number.
 2. Varieties.
- Nitrification.

PURIFICATION AND DISPOSAL OF SEWAGE.

1. Dilution.

This method is allowable for cities situated on the sea or on rivers whose flow is very large as compared with the sewage (100:1) and the unfiltered water of which is not used as a water supply.

2. Sewage farming.

3. Chemical precipitation.

4. Intermittent filtration.

Needs sandy soil.

5. Septic tank.

6. Contact bed treatment.

7. Continuous filtration:

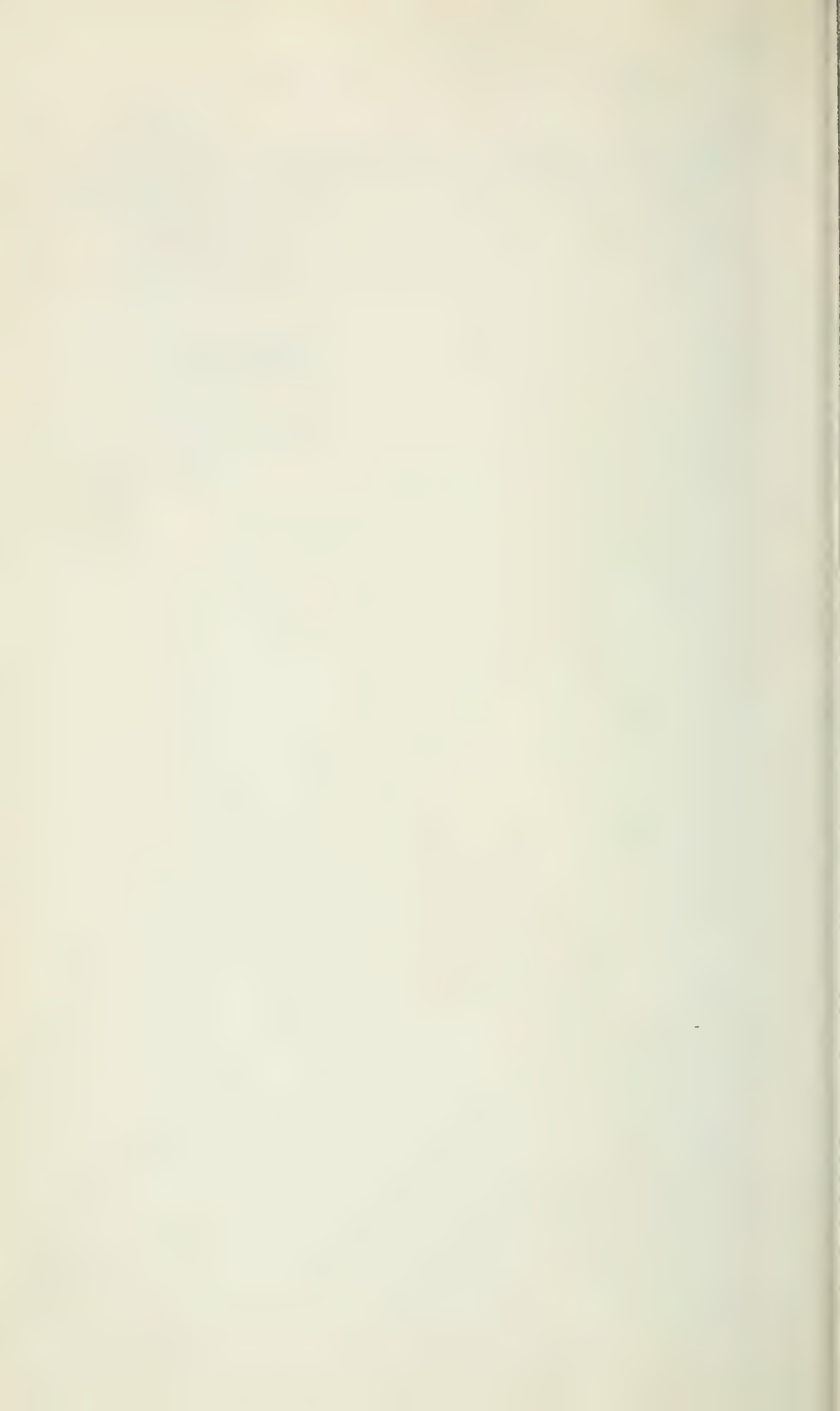
a. Scott-Moncrieff system.

b. The Ducat.

c. Whitaker & Bryant.

d. F. Stoddart.

e. G. Salford.



MILK—

1. Histology.
2. Bacteria in milk:
 - Number.
 - Origin.
 - Varieties.
3. Fermentation—
 - Lactic acid.
 - Butyric acid.
 - Sweet curdling.
 - Abnormal.
4. Pasteurization:
 - Theory and practical uses.
 - Changes produced in milk.
5. Count and study colonies in fresh milk and milk bought in open market.
 - Pasteurize, then count and study colonies.
6. Sterilization of milk by heat; practical application and changes produced in milk.
7. Milk preservatives.
8. Diseases conveyed by milk.

PRINCIPLES AND PRACTICE OF DISINFECTION AND STERILIZATION.

Physical agents.

1. Sunlight—

Expose spores of anthrax, subtilis, etc.

Expose nonspore-bearing organisms as typhoid, diphtheria, etc., to the sunlight in thin films and for penetration. Note intensity of the light, temperature, dryness, and other conditions. Plant in bouillon.

2. Electricity—

Expose slips and cultures to various currents.

Expose to electric light.

Expose to X-rays.

3. Dryness and dry heat—

Expose slips, or threads with spore-bearing and nonspore-bearing organisms to:

a. Dryness at room conditions.

b. Dry in incubator at 37° C.

c. Dry over sulphuric acid.

d. Dry heat at 5° C.,

15° C.,

37° C.,

for various times.

e. Expose paper slips saturated with—

a. Decomposing urine,

b. Sewage,

c. Garden earth,

to 150° C. for one hour to test power of sterilization of this temperature.

Hot-air sterilizer.

NOTE.—Plant in bouillon and keep one week for growth.

4. Moist heat—hot and boiling water and steam:

Expose typhoid, diphtheria, and other nonspore-bearing organisms to 50°, 60°, 70°, 80°, and 100° C. moist heat for variable times; plant in bouillon.

Expose anthrax, subtilis, and other spores to 70°, 80°, 90°, and 100° C. moist heat for variable times; plant in bouillon.

5. Theory, mechanics, and practical application of steam in—

a. Koch steamer.

b. Arnold steam sterilizer.

c. Autoclave (steam under pressure).

d. Steam chamber (steam under pressure).

e. Superheated steam.

Make practical tests in each.

TESTING ANTISEPTICS—

If the substance belongs to the Cresol group, prepare 1 per cent, 2 per cent, etc., solutions of the substance in a set of bouillon tubes.

If the substance belongs to the metallic salts, make $\frac{1}{5000}$, $\frac{1}{3000}$, $\frac{1}{2000}$, $\frac{1}{1000}$, $\frac{1}{200}$, etc., solutions in a set of bouillon tubes.

Inoculate with:

- a. Decomposing urine.
- b. Sewage.
- c. Garden earth.
- d. Typhoid.
- e. Pus cocci.
- f. Anthrax spores, etc.

Grow at favorable temperature and record each day the appearance of growth, and make report on the following plan:

Name of substance.—Strength of solution.—Temperature.	Days.							
	1.	2.	3.	4.	5.	6.	7.	8.
Sewage	—	—	—					
Garden earth	—	+	+					
Decomposing urine	+	+	+					

— means no growth; + means growth.

TESTING GERMICIDES—

Saturate silk threads,
 paper slips,
 glass slips, etc., with
 subtilis spores,
 anthrax spores,
 typhoid bacillus,
 diphtheria bacillus,
 pus cocci, etc.

Expose to the solutions of germicide in varying dilutions and for varying times
 at constant temperature, and at the same dilution at varying temperatures.

Wash or neutralize the germicide.

Plant in bouillon.

Incubate.

Report growth upon similar table to antiseptics.

Test the following upon the above plan—

- A. Bichlorid of mercury.
- B. Carbolic acid and tricresol.
- C. Lime.
- D. Copper and iron sulphates.
- E. Formalin.

GASEOUS DISINFECTION—

A. Formaldehyd:

- a.* Chemistry and physics.
- b.* Sheet method.
- c.* Generator—
 - 1. Kuhn lamp.
- d.* Regenerators without pressure—
 - 1. Trenner-Lee.
 - 2. Lentz.
- e.* Regenerators with pressure—
 - 1. Autoclave.
- f.* Heating paraform.
- g.* Spraying.

B. Sulphur dioxid (SO_2):

- a.* Liquid sulphur dioxid.
- b.* Burning sulphur, pot method.
- c.* Sulphur furnace.

C. Hydrocyanic acid gas.

D. Chlorin gas.

E. Ozone and oxygen.

INSECTICIDES—

- A. Tobacco smoke.
- B. Pyrethrum.
- C. Hydrocyanic acid.
- D. Formaldehyd gas.
- E. Sulphur dioxid.
- F. Coal oil.
- G. Arsenical compounds.
- H. Phosphorus.
- I. Cobalt salts.
- J. Carbon bisulphid.

Ants.

Mosquitoes.

Roaches.

Fleas.

Flies, etc.



1. THE DISINFECTION OF HOUSES, SHIPS, AND OBJECTS.
2. THE DISINFECTION AND PROPHYLAXIS AGAINST THE COMMUNICABLE DISEASES, ESPECIALLY.

- a.* Yellow fever.
- b.* Cholera.
- c.* Plague.
- d.* Smallpox.
- e.* Tuberculosis.
- f.* Typhoid fever.
- g.* Malaria.
- h.* Dysentery.
- i.* Diphtheria.
- j.* Pneumonia.
- k.* Leprosy.
- l.* Anthrax.
- m.* Tetanus.
- n.* Dengue.
- o.* Relapsing fever.
- p.* Typhus fever.
- q.* Scarlet fever.
- r.* Measles.

Including channels of introduction and elimination.

Viability.

Disinfection.

Prophylaxis.

Management of epidemics.

Quarantine.

RABIES—

Study in dogs.

Study in rabbits.

Prepare spinal cords for preventive inoculation.

Principles and methods of Pasteur treatment.

VACCINATION (*vaccinia*)—

- A. History.
- B. Methods of production:
 - Vaccine lymph.
 - Vaccine pulp—
 - Dry points.
 - Glycerinated pulp.
- C. Technique of vaccination.
- D. Immunity produced.
- E. Bacteriologic and microscopic study of vaccine matter.
- F. Bodies in epithelial cells—cornea of rabbits.

The examination of vaccine under the law of July 1, 1902.

Note the name of maker, license number, kind of virus, date of return, etc.

a. Count the number of colonies per point.

Immerse the point in 1 cc. physiological salt solution 15 minutes to soften the vaccine matter.

Scrape well and agitate to break up clumps, etc.

Plate the emulsion thus obtained in three Petri dishes as follows:

5 drops in first.

10 drops in second.

Remainder in third.

Then plant in melted agar, incubate at 37° C. for three *days, then room temperature for two days.

Count number and determine character of colonies.

b. Count number of colonies per capillary tube.

Wash contents of tube into 1 cc. sterile water.

Agitate to break up clumps.

Plate in agar as above.

c. Plant the entire contents of 10 tubes or 10 points in 100 cc. of freshly prepared and recently boiled glucose bouillon.

Incubate at 37° C.

At the end of 48 hours inoculate upper growth into peritoneal cavity of a rabbit, using 1 cc. per 1,000 gm. of rabbit.

If rabbit sickens or dies determine cause of the infection.

At the end of seven days filter the bouillon growth through porcelain and inoculate 0.2 cc. of the filtrate subcutaneously into a mouse for tetanus toxin.

MALARIA AND MOSQUITOES—

1. Diagnosis.
2. Blood technique.
3. Relation to mosquito:
 - a. Tertian.
 - b. Quartan.
 - c. Estivo-autumnal.

Mosquitoes—

Anatomy—dissections, fresh specimens.

Sections in paraffin.

Development and raising.

Classification.

Diagnosis, especially:

- a. *Culex*.
- b. *Anopheles*.
- c. *Stegomyia*.

A. Malaria—the *Anopheles*:

Study *Anopheles* one each day after biting a malarial case.

Tertian.

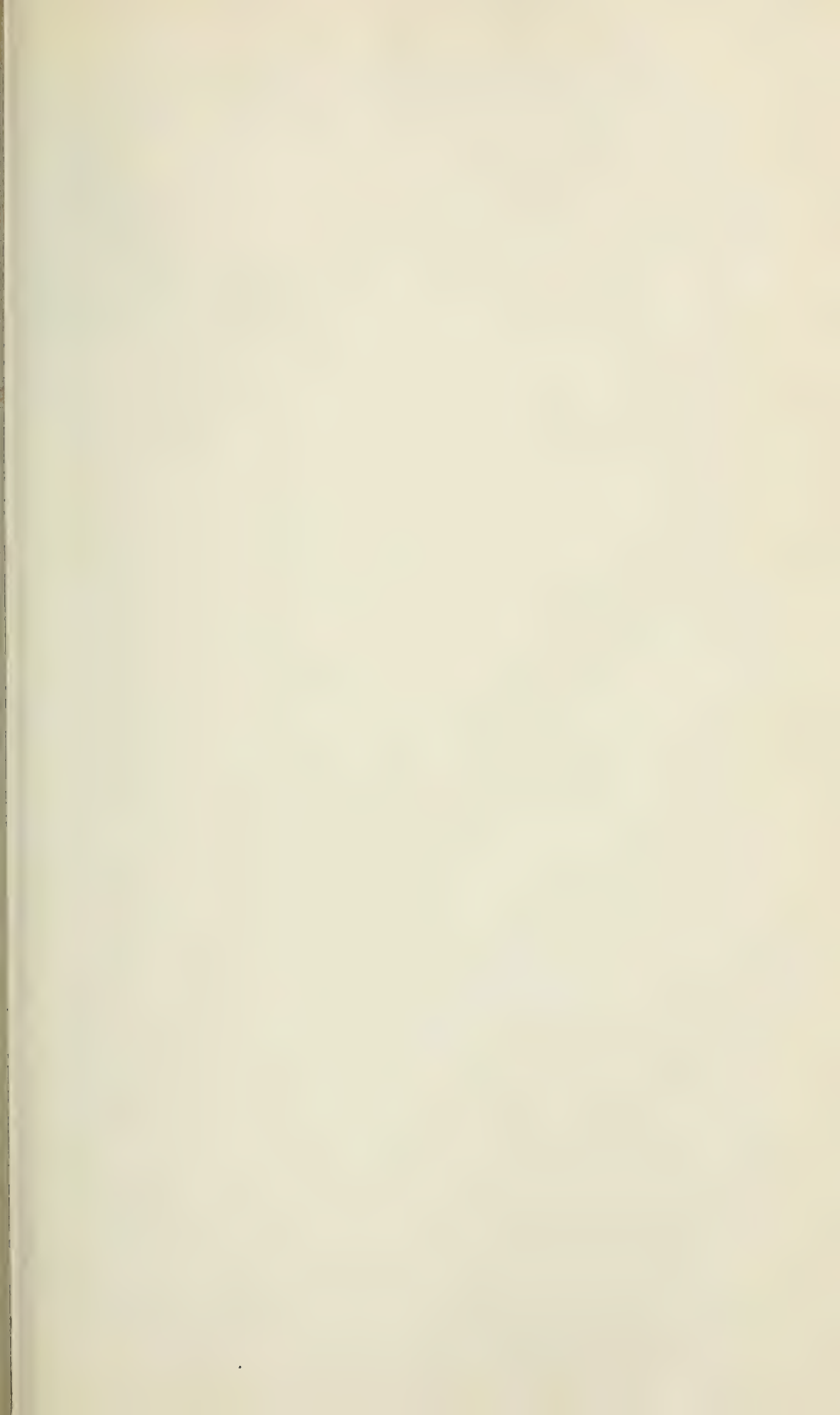
Quartan.

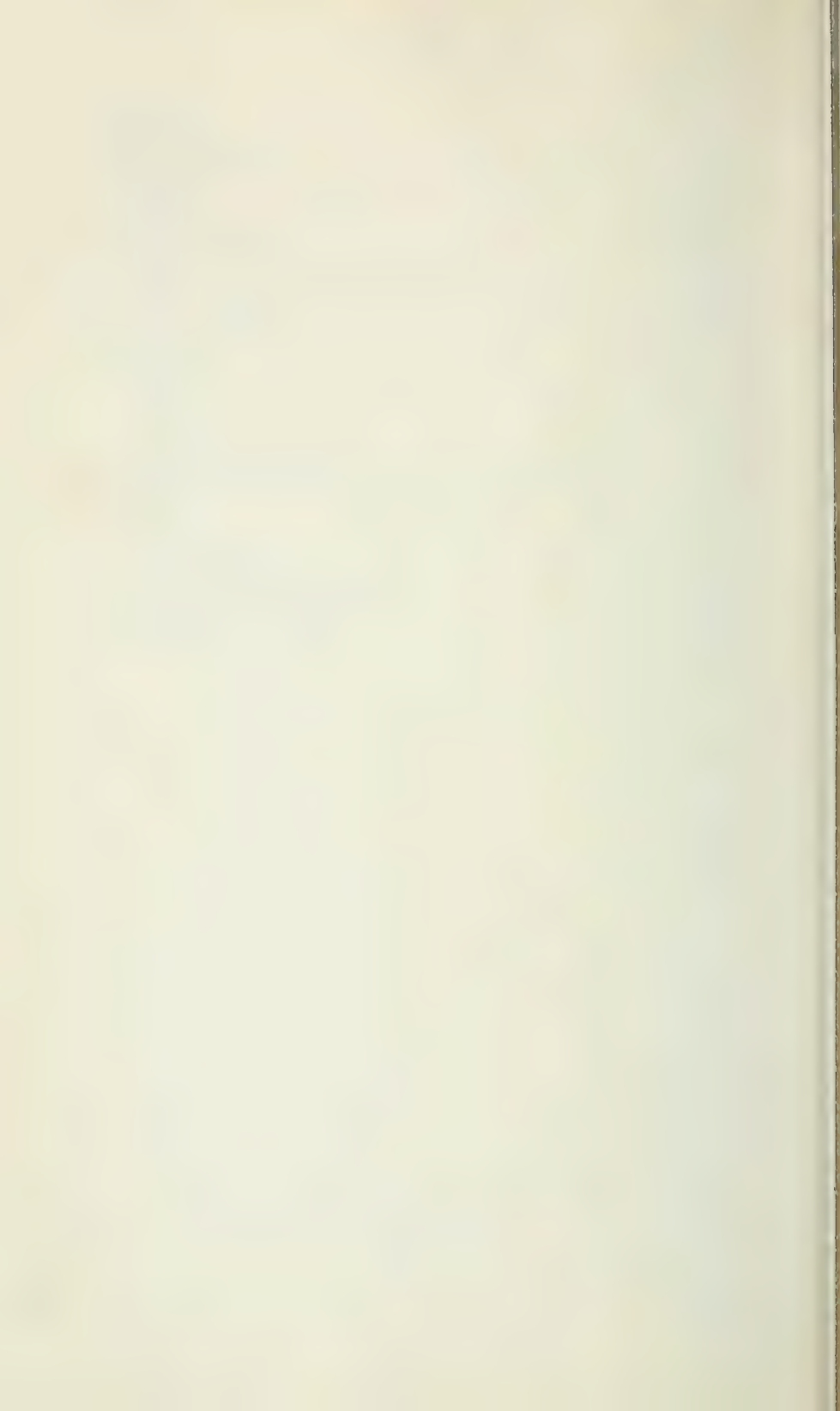
Estivo-autumnal.

B. Yellow fever and the mosquito.

C. Filaria and the mosquito.

D. Dengue and the mosquito.





INSECTS AND TICKS AS FACTORS IN TRANSMITTING DISEASE—

The mosquito.

The fly.

The ant.

The flea.

The bedbug.

The roach.

The tick, etc.

Texas fever—*Piroplasma bigeminum*.

Spotted fever of Bitter Root Valley, Mont.

Sleeping sickness—Trypanosomiasis.

TRYPANOSOMES—

Inoculate rat with *Trypanosoma Lewisi*.

Sleeping sickness,

Dourine.

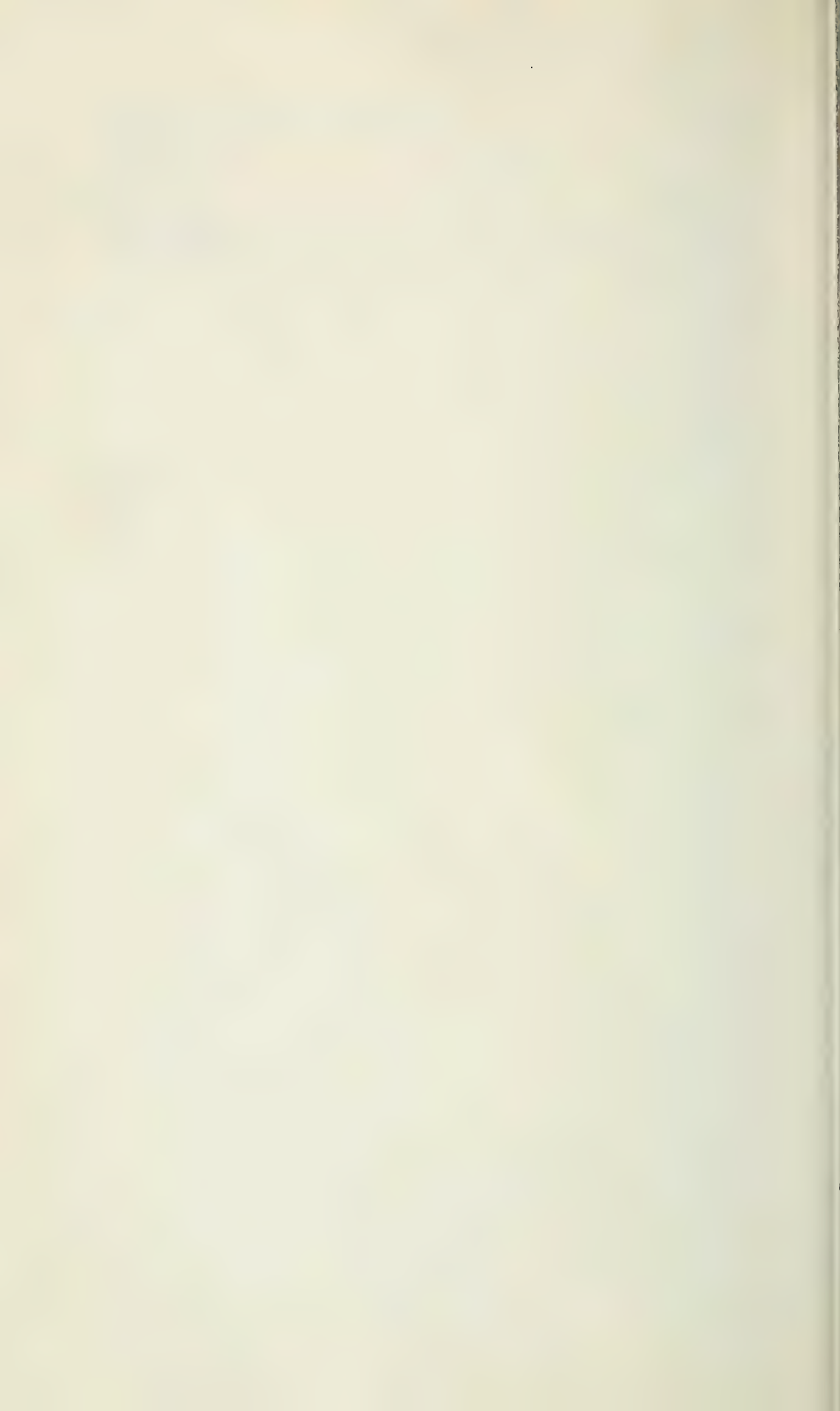
Surra.

Nagana.

Mal de caderas.

Culture of trypanosomes on water of condensation in blood-ajar.





FILARIAL EMBRYOS ("Filaria sanguinis hominis") in the blood.

Filaria Bancrofti Cobbold, 1877.

Filaria diurna Manson, 1891.

Filaria perstans Manson, 1891.

Filaria Demarquayii Manson, 1895.

Dracunculus mediensis (Linnæus, 1758). [Guinea worm.]

Relapsing fever. (*Spirocheta Obermeieri*.)

FERMENTS—

Organized.

Unorganized—enzymes.

A. *Amylolytic*:

Ptyalin.

Diastase.

Amylopsin.

Convert starch and glycogen into sugar.

B. *Proteolytic*:

Pepsin.

Trypsin.

Bacterial peptonizing enzymes.

Convert proteids into peptones.

C. *Steatolytic*—steapsin.

Split fats into fatty acids and glycerin.

D. *Invertin*—in intestinal juice and yeast cells.

Convert cane sugar, maltose, lactose into glucose.

E. *Coagulation*:

Rennet.

Fibrin ferment.

Convert soluble into insoluble ferments.

F. *Alcoholic ferments*:

Saccharomyces.

Converts carbohydrates into alcohol, carbon dioxid, etc.

Fermentation in—

Wine.

Beer.

Vinegar, acetic.

Milk:

Lactic.

Butyric.

Koumys.

Kefir.

IMMUNITY-

Natural.

Inherited.

Acquired:

Active.

Passive.

Toxin immunity:

Toxemia.

Antitoxins.

Bacterial immunity:

Bacteriemia.

Bacteriolysins.

Theories explaining immunity:

A. Alexins, or bactericidal substances in the blood.

Nuttall and Buchner.

B. Chemical theory—Ehrlich's side chains.

Antitoxin immunity:

Receptors.

Toxin—

Haptophore group.

Toxophore group.

Cytolytic immunity.

1. Complement, alexin or cytase; normally present, not specific for species, thermolabile.

2. Immune body, amboceptor, intermediary body, sensitizer, fixative, preparative, additive, desmon.

Produced by process of immunization, specific and thermostabile.

C. Biological theory—phagocytosis of Metchnikoff.

Ameboid motion.

Digestive vacuoles—formation of acid.

Phagocytes:

Free phagocytes—

Microphages—

Polymorphonuclear neutrophiles.

Eosinophiles.

Macrophages—

Large mononuclear lymphocytes.

Transitional forms.

Epithelioid cells.

Fixed phagocytes—

Connective tissue corpuscles.

Vascular endothelium.

Kupfer's cells, etc.

Small lymphocytes and mast cells lack ameboid motion and are not phagocytic.

Chemotaxis—

Positive.

Negative.

D. Enzyme theory—immunizing proteid of Emerich and Löw.

E. Retention theory.

F. Exhaustion theory.

TOXINS—

Toxins, toxones, toxoids, etc.:

a. Ptomaines.

b. Leucomaines.

c. Tox-albumens.

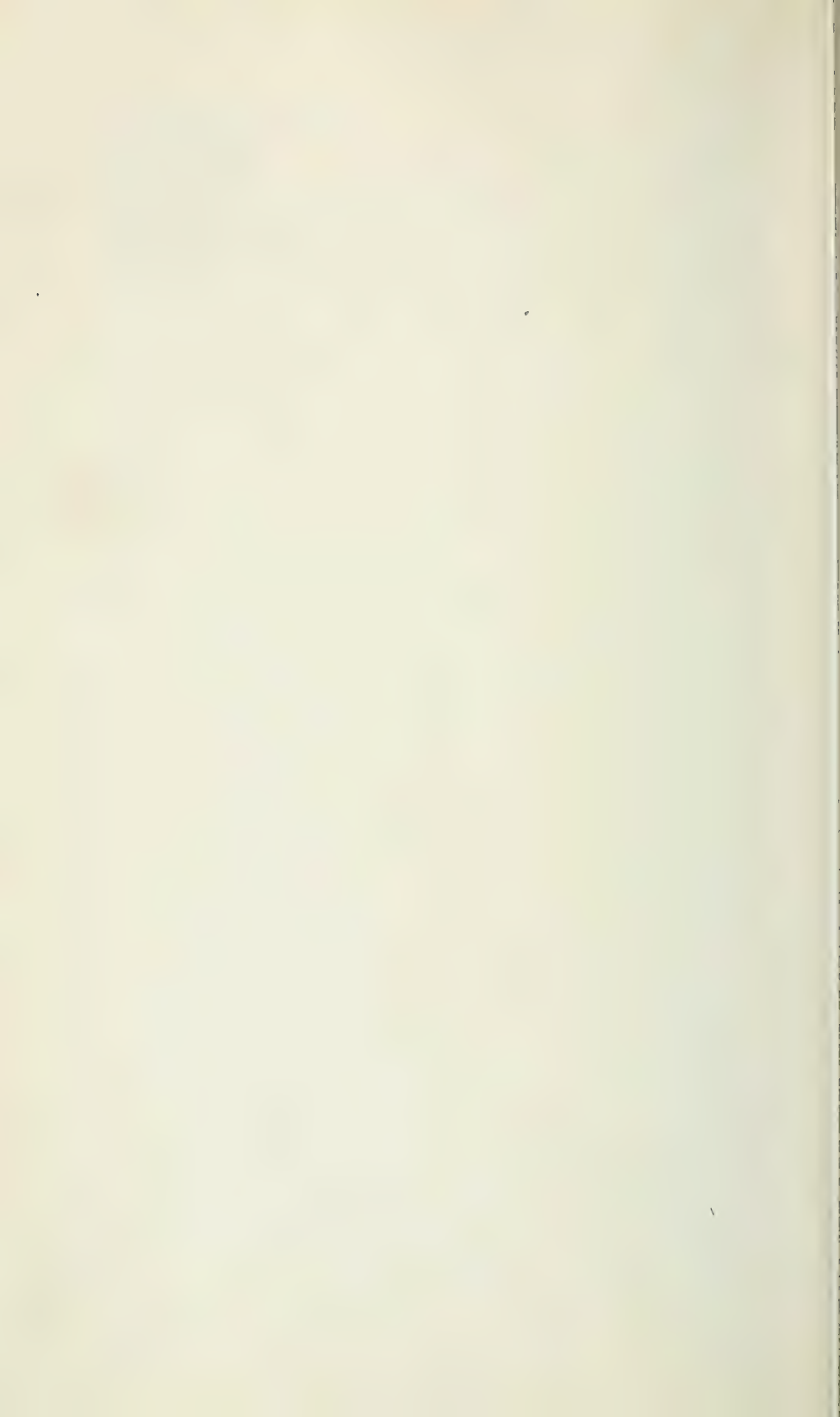
d. Enzymes.

Ricin (castor bean).

Abrin (jaquerity bean).

Snake venom.





CYTOLYSINS AND CYTOLYSIS—

- a.* Bacteriolysins.
- b.* Hemolysins.
- c.* Leucolysins.
- d.* Spermatolysins, etc..

TRANSPORTATION OF DISEASED TISSUES AND BACTERIOLOGIC SPECIMENS, ETC., BY MAIL AND EXPRESS.

The Regulations of the Post-Office Department, Order No. 176, March 2, 1900.

Mailing cases.

Methods of sending dry specimens.

Methods of sending moist specimens.

Methods of preparing and forwarding samples for bacteriologic study.

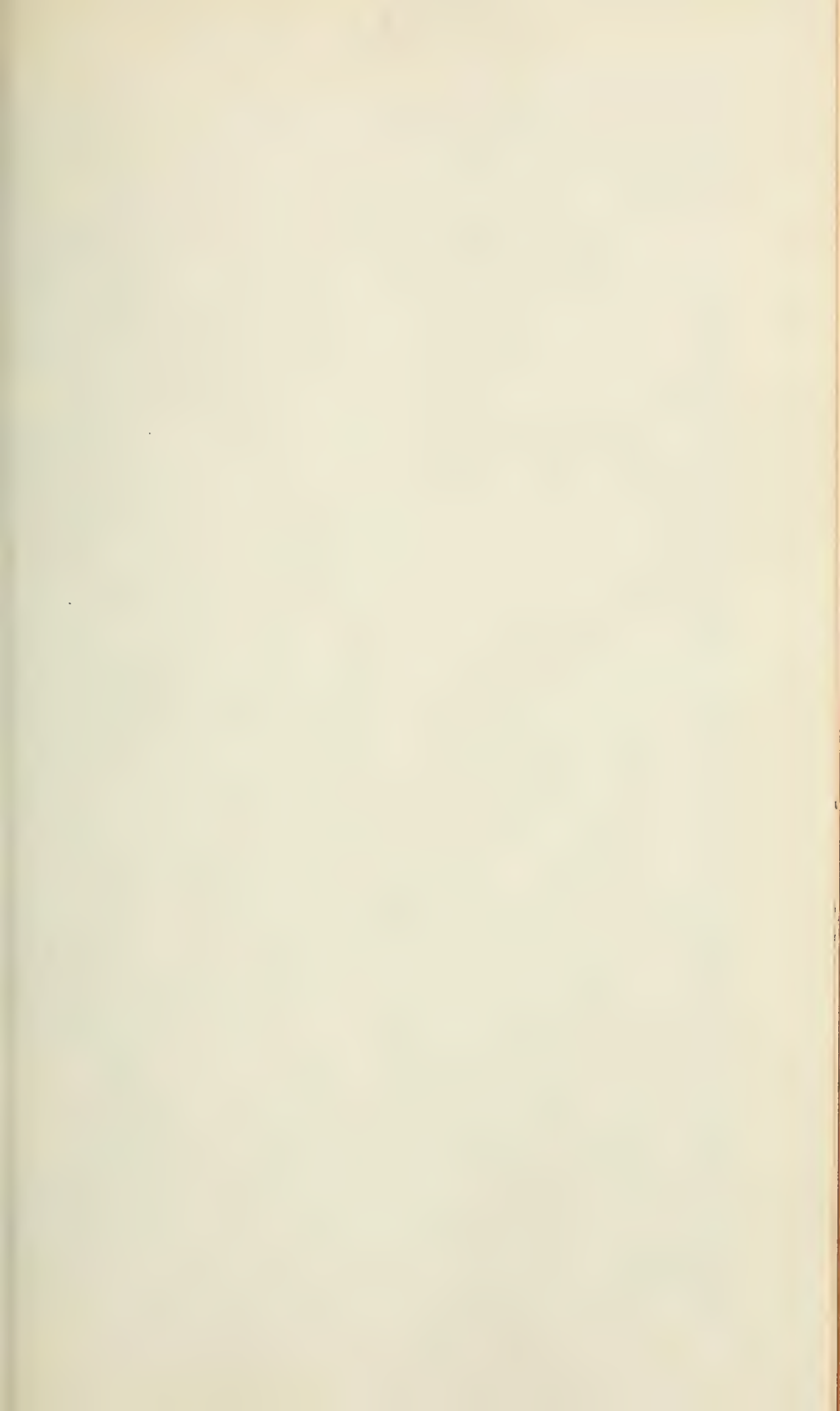
Methods of preparing and forwarding samples for histologic study.



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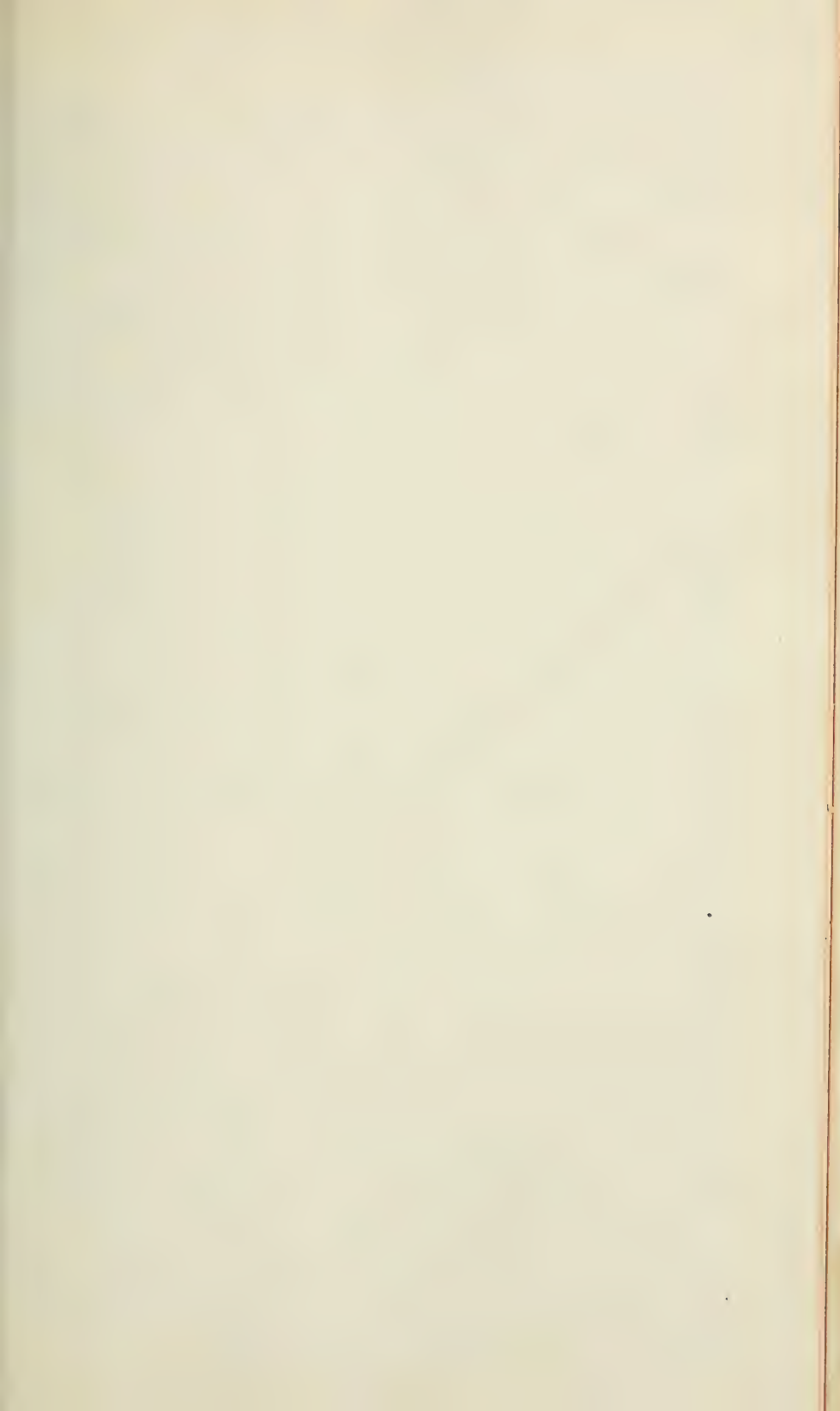
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7
TREASURY DEPARTMENT.
Public Health and Marine-Hospital Service of the United States.
WALTER WYMAN, Surgeon-General.

HYGIENIC LABORATORY.—BULLETIN No. 9.

M. J. ROSENAU, Director.

SEPTEMBER, 1902.

PRESENCE OF TETANUS

IN

COMMERCIAL GELATIN

BY

JOHN F. ANDERSON.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1902.



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The Hygienic Laboratory was established in New York, at the Marine Hospital on Staten Island, August, 1887. It was transferred to Washington, with quarters in the Butler Building, June 11, 1891, and a new laboratory building, to be located in Washington, was authorized by act of Congress, March 3, 1901.

By act of Congress, approved July 1, 1902, the name of the "United States Marine-Hospital Service" was changed to the "Public Health and Marine-Hospital Service of the United States," and three new divisions were added to the Hygienic Laboratory.

The following *bulletins* [Bull. Nos. 1-7, 1900 to 1902, Hyg. Lab., U. S. Mar.-Hosp. Serv., Wash.] have been issued:

- No. 1.—Preliminary note on the viability of the *Bacillus pestis*. By M. J. Rosenau.
 - No. 2.—Formalin disinfection of baggage without apparatus. By M. J. Rosenau.
 - No. 3.—Sulphur dioxide as a germicidal agent. By H. D. Geddings.
 - No. 4.—Viability of the *Bacillus pestis*. By M. J. Rosenau.
 - No. 5.—An investigation of a pathogenic microbe (*B. typhi murium* Danyz) applied to the destruction of rats. By M. J. Rosenau.
 - No. 6.—Disinfection against mosquitoes with formaldehyd and sulphur dioxide. By M. J. Rosenau.
 - No. 7.—Laboratory technique: Ring test for indol, by S. B. Grubbs and Edward Francis; Collodium sacs, by S. B. Grubbs and Edward Francis; Microphotography with simple apparatus, by H. B. Parker.
 - No. 8.—Laboratory course in bacteriology and pathology. By M. J. Rosenau.
- In citing these bulletins, beginning with No. 8, bibliographers and authors are requested to adopt the following abbreviations: Bull. No. —, Hyg. Lab., U. S. Pub. Health & Mar.-Hosp. Serv., Wash., pp. —.

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TREASURY DEPARTMENT.

Public Health and Marine-Hospital Service of the United States.

WALTER WYMAN, Surgeon-General.

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PRESENCE OF TETANUS IN COMMERCIAL GELATIN.

[BY JOHN F. ANDERSON, ASSISTANT SURGEON, UNITED STATES PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE.]

Gelatin injections are now used rather extensively, in Europe especially, as a means of treatment for aneurism and as a direct and prophylactic hemostatic. It is generally used in a 2 per cent solution in water, boiled immediately before use, and, as a hemostatic, injected subcutaneously. There seems a great variation in the amount of solution used, some using 200 c. c. and others as high as 1,000 c. c.

Gelatin is a substance obtained from the nitrogenous portions of bone, hides, connective tissue, etc. The collagen when boiled is changed to gelatin. Glue is impure gelatin to which has been added some preservative and some substance to increase its power of adhesion. Bone and hide gelatin are the two principal kinds of gelatin. Isinglass is gelatin made from the bladders of sturgeons. According to Whipple (5), the general process of manufacturing hide gelatin is as follows:

The hide scraps are first macerated and subjected to the action of a solution of lime or caustic soda in pits for two or three weeks. This dissolves most of the blood and saponifies the fats. The excess of lime or soda is then largely removed by washing and the solution steamed to dissolve the gelatin, but an excess of heat is avoided. Sulphurous acid is used to bleach the gelatin. When of sufficient strength, the gelatin is allowed to harden in molds or on slabs, and is ultimately dried in sheets on wire nets. Bone gelatin is made in a somewhat similar manner. The bones are crushed, boiled, treated with hydrochloric acid, and the gelatin is dissolved as before, washed, bleached, and dried in sheets. The process requires a number of weeks.

According to the National Dispensatory, gelatin is made by boiling in water for a long time bone cartilage, animal skin, tendons, and ligaments. These substances become soluble in the boiling water, and when the mass is allowed to cool, form a jelly. The animal tissues are placed upon a sieve or perforated diaphragm some distance from the bottom of the boiler. When the solution has become sufficiently saturated it is drawn off and allowed to cool, and the jelly is then cut into thin sheets and placed on wire nettings to dry. While so exposed to the air for drying it could easily become infected with tetanus spores, as the gelatin is often manufactured in conjunction with the other procedures that go on in a large meat-packing house.

Kuhn (1) reported a case of tetanus following the injection of gelatin in a hemophiliac.

Gerulanos, Georgi, and Lorenzo (2) report four cases of tetanus following the injection of gelatin for the purpose of arresting hemorrhage

after operations such as for subphrenic abscess and for disease of the urinary tract. In one of these last four cases the organism was obtained from the seat of injection.

Drs. Hochhalt and Herezel (3) report a case of tetanus on the seventh day after an injection of 2 per cent gelatin following splenectomy.

Dr. Laszlo Deatsch (3) studied bacteriologically the gelatin used in the last-named case, and found that after being boiled for five minutes and then grown anaerobically it contained an anaerobic, spore-bearing bacillus. He advises that gelatin, to be used as a hemostatic, be inoculated with bacillus subtilis before sterilization, and, as this organism is more resistant to heat than that of tetanus, if there is no growth of subtilis the gelatin can be used without fear of tetanus.

Drs. Levi and Brun (4), of Strasbourg, examined six samples of gelatin and in four found tetanus bacilli. They found that the spores of the tetanus bacilli which they isolated were able to resist streaming steam for a longer period than eight minutes.

Six different makes of gelatin were purchased in the open market and, with the stock laboratory gelatin, an investigation was begun with regard to the presence of tetanus in the same. Ten grams of each sample of gelatin were placed in 100 c. c. of glucose bouillon and heated at 50° C. until dissolved, then rendered slightly alkaline to litmus and heated to 80° C. for ten minutes to endeavor to kill all nonspore-bearing organisms; the flasks at the end of ten minutes were quickly placed in a Novy jar and boiled in vacuo to expel all of the air; the jars were then placed in the incubator and kept at 37° C. for one week. On the seventh day the flasks were removed from the jars. Three of the flasks remained sterile; of the other four, three showed an end-spore bearing rod, the spores of two of them being oval, and the third round with a very fine rod; this last stained by Gram.

The same day .5 c. c. of each culture was injected subcutaneously into white rats, but beyond making them very sensitive to sudden noises for one or two days, no results were noted. Two days later .5 c. c. of the culture containing the round, end spore rod was put into a white mouse. The mouse was found dead the next morning. Bouillon tubes were inoculated from the site of inoculation and with the heart's blood, but both remained sterile. Two drops of this culture, which we will call No. 1, were put into a tube of bouillon, heated to 80° C. for five minutes, and from this glucose agar plates were made and incubated for seven days at 37° C. in a Novy jar. At the end of a week two of the plates showed deep, oval colonies; stained smears showed these to be a fine rod with a round end-spore.

A flask and three tubes of *freshly* made bouillon were inoculated from the plates; the flask was heated to 80° C. for ten minutes; the tubes were not heated after inoculation. Flask and tubes were grown in a Novy jar as before. One drop of the bouillon growth from one of the tubes was injected into the right side of a mouse; mouse died next

morning with signs of tetanus, such as stiff tail and retraction to right side. Smears made from the site of inoculation showed the presence of a thin rod with a round end-spore. Decreasing doses were put into white mice on successive days until finally it was found that .000022 c. c. would kill a mouse with typical symptoms of tetanus in four days, with an incubation period of about thirty-six hours.

SUMMARY AND CONCLUSIONS.

Seven samples of gelatin examined; one showed tetanus spores.

Two samples showed an oval end-spore rod, whose identity was not proved, but in stained specimens it would be hard to distinguish from tetanus, if indeed not tetanus with diminished virulence.

In tetanus investigations it is important to use *freshly* made bouillon, as the organism is apt not to germinate in bouillon over ten days old.

The thermal death point of the organism isolated was found to be between twenty and thirty seconds at 100° C.

It is important, therefore, that gelatin to be used for injections should be boiled at least ten minutes on account of the variability of the thermal death point in different species of tetanus. Whether this amount heating impairs in any way the hemostatic power of gelatin has not been settled, but in case it does it is believed that the danger from tetanus more than overbalances its therapeutic value.

It is suggested that when, as in hospitals, there is likelihood of gelatin injections being used for hemostatic purposes the gelatin solution be sterilized by the fractional method on three successive days and kept ready for use in sterile containers.

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TREASURY DEPARTMENT.

Public Health and Marine-Hospital Service of the United States.

WALTER WYMAN, Surgeon-General.

W. H. Phillips
HYGIENIC LABORATORY.—BULLETIN No. 10.

M. J. ROSENAU, Director.

February, 1903.

REPORT

UPON THE

PREVALENCE AND GEOGRAPHIC DISTRIBUTION OF HOOKWORM DISEASE

(*Uncinariasis or Ancylostomiasis*)

IN THE

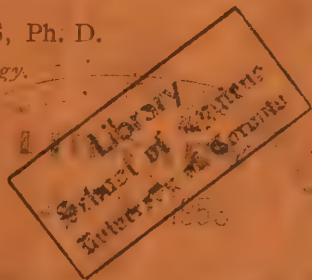
UNITED STATES.

(SECOND EDITION.)

BY

CH. WARDELL STILES, Ph. D.

Chief of Division of Zoology.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1903.

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No. 9.—Presence of tetanus in commercial gelatin. By John F. Anderson.

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Public Health and Marine-Hospital Service of the United States.

WALTER WYMAN, Surgeon-General.

HYGIENIC LABORATORY.—BULLETIN No. 10.

M. J. ROSENAU, Director.

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1903.

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SUMMARY

Convinced from theoretical deductions that hookworm disease (uncinariasis) must be more or less common in the South, a trip was made from Washington, D. C., to Ocala, Fla., stopping at penitentiaries, mines, farms, asylums, schools, and factories, and the fact was established that the chief anemia of the Southern rural sand districts is due to uncinariasis, while clay districts and cities are not favorable to the development of this disease.

In the Old World, hookworm disease was probably known to the Egyptians nearly three thousand five hundred years ago, but its cause was not understood until about the middle of the nineteenth century, when it was shown to be due to an intestinal parasite, *Ancylostoma duodenale*. Until 1893 no authentic cases of this disease were recognized as such in the United States, but between 1893 and 1902 about 35 cases were diagnosed. In 1902 it was shown that a distinct hookworm, *Uncinaria americana*, infests man in this country, and this indicated very strongly that the disease must be present although not generally recognized. It is now established that in addition to the few cases of Old World hookworm disease imported into the United States we have in the South an endemic uncinariasis due to a distinct cause, *Uncinaria americana*. This disease has been known for years in the South and can be traced in medical writings as far back as 1808, but its nature was not understood. Some cases have been confused with malaria, others have been attributed to dirt-eating.

The hookworms are about half an inch long. They live in the small intestine, where they suck blood, produce minute hemorrhages, and in all probability also produce a substance which acts as a poison. They lay eggs which can not develop to maturity in the intestine. These ova escape with the feces and hatch in about twenty-four hours; the young worm sheds its skin twice and then is ready to infect man. Infection takes place through the mouth, either by the hands soiled with larvae or by infected food. Infection through the drinking water may possibly occur. Finally, the larvae may enter the body through the skin and eventually reach the small intestine.

Patients may be divided into light cases, in which the symptoms are very obscure; medium cases, in which the anemia is more or less marked, and severe cases, represented by the dwarfed, edematous, anemic dirt-eater. Infection occurs chiefly in rural sand districts. Above the frost line the symptoms are more severe in summer than in winter, and whites appear to be more severely affected than negroes. Persons who come in contact with damp earth are more commonly infected than others, so that the disease is found chiefly among farmers, miners, and brickmakers. Severe cases are more common in women and children than in men over 25 years of age. Uncinariasis is a disease which occurs in groups of cases, and if one case is found in a family the chances are that other members of the same family are infected.

The testimony of patients severely infected is unreliable. Recalling that any one or more symptoms may be absent or subject to variation, it may be noted that the period of incubation (at least before the malady can be diagnosed by finding the eggs) is from four to ten weeks. Stages are not necessarily distinctly defined, but are described as (1) stage of purely local symptoms, corresponding to the light cases; (2) stage of simple anemia, corresponding to the medium cases; and (3) dropsical stage, corresponding more or less to the severe cases. The duration of the disease after isolation from the source of infection has been traced for six years and seven

months; how much longer infection will last is not established. If a patient is subject to cumulative infection, the disease may last five, ten, or even fifteen years, and in case of light infection perhaps longer.

External appearance.—In extreme cases there is a general lack of development; skin waxy white to yellow or tan; hair is found on the head, but is more or less absent from the body; breasts are undeveloped; nails white; external genitalia more or less rudimentary; face anxious, may be bloated; conjunctivæ pale; eyes more or less dry, pupil dilates readily; membranes pale according to the anemia; teeth often irregular; tongue frequently marked with purple or brown spots; cervical pulsations prominent; thorax emaciated; heart beats often visible; abdomen frequently with "pot belly;" extremities emaciated, frequently edematous, and with wounds or ulcers of long standing.

Urine 1010 to 1015; in advanced cases albumin without casts; acid or alkaline.

Feces reddish brown, contain eggs, and may contain blood.

Circulatory system.—Anemia pronounced, according to degree and duration of infection; blood watery, with decreased red blood corpuscles and with eosinophilia; "heart disease" very commonly complained of; hemic murmurs present; pulse 80 to 132 per minute.

Temperature.—Subnormal, normal, or to 101° or 102° F.

Respiratory system.—Breathing may be difficult, slow, or increased to as high as 30.

Muscular system.—Emaciation and great physical weakness.

Digestive system.—Appetite poor to ravenous; abnormal appetite often developed for pickles, lemons, salt, coffee, sand, clay, etc.; pain in epigastrium; constipation or diarrhea.

Nervous system.—Headache, dizziness, nervousness, mental lassitude, and stupidity.

Genital system.—Menstruation irregular or absent; if present, it occurs chiefly in winter; there is a marked tendency to abortion.

Diagnosis.—The safest plan is to make a microscopic examination of the feces to find the eggs; or, if feces are placed on white blotting paper, a blood-like stain will be noticed.

Treatment.—Thymol, or male fern (or ? calomel); iron, and good food.

Prognosis.—Good, if patient is not too far gone at time of treatment.

Lethality.—Not yet determined.

Prevention.—Treat all cases found and dispose of feces.

Economically, uncinariasis is very important. It keeps children from school, decreases capacity for both physical and mental labor, and is one of the most important factors in determining the present condition of the poorer whites of the sand and pine districts of the South.

The disease is carried from the farms to the cotton mills by the mill hands, but does not spread much in the mills; nevertheless, it causes a considerable amount of anemia among the operatives.

REPORT UPON THE PREVALENCE AND GEOGRAPHIC DISTRIBUTION OF HOOKWORM DISEASE (UNCINARIASIS OR ANCHYLOSTOMIASIS) IN THE UNITED STATES.

By CH. WARDELL STILES, Ph. D.,

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INTRODUCTION.

Thoroughly convinced from theoretical zoologic considerations, especially of a faunistic nature, that uncinariasis must be a more or less common disease in the Southern portion of the United States, I requested instructions from Surgeon-General Wyman to study the subject in a field investigation. The desired authorization was received and the results of the work are contained in this paper.

DEFINITION.

Uncinariasis is a specific zooparasitic disease found especially in tropical and subtropical sand areas, and caused by hookworms (genus *Uncinaria*) which inhabit the small intestine. Its chief symptoms are: Anemia, with the circulatory symptoms found in all extreme anemias, namely, dizziness, palpitation, hemic murmurs; great weakness, in some cases with considerable emaciation; colicky pains in the abdomen; perverted appetite, such as "dirt-eating;" constipation or diarrhea, stools sometimes brownish or bloody; nausea; edema. The only positive diagnosis is by finding the parasite or its eggs in the stools. It may affect any class of patients, but is more frequent in persons whose daily life brings them in contact with damp earth (children, farmers, miners, brickmakers, excavators, etc.).

TERMINOLOGY.

The disease now under discussion is known by a number of different names, but uncinariasis^a should be adopted as the more correct technical designation. Among the names frequently applied to it, the

^aLooss (1902) has recently attempted to suppress the term "uncinariasis" in favor of anchylostomiasis, his view being that the genus *Ancylostoma* is distinct from *Uncinaria*. His suggestion does not help matters much at present. Even if the zoological genera are recognized as distinct, uncinariasis would still exist in man, while among animals it would be still more common than anchylostomiasis. Further, the two genera would probably have to be united in a subfamily, which could then be called "Uncinariinae," and uncinariasis could then signify any infection of any

following may be mentioned in particular: Anchylostomiasis, ankylostomiasis, brickmakers' anemia, Egyptian chlorosis, miners' anemia, miners' cachexia, tunnel anemia, St. Gothard tunnel disease, tropical chlorosis, hookworm disease, and tunnel disease. (See also pp. 31, 32, 96.)

HISTORICAL REVIEW.

In order to understand the exact status of the subject of uncinariasis, it will be well to take a brief historical review of hookworms in general, hookworm disease in general, and hookworm disease in the United States.

BRIEF REVIEW OF HOOKWORMS.

It is quite probable that the ancient Egyptians, nearly thirty-five hundred years ago, were acquainted with the parasites which we now call hookworms. From a zoological standpoint, however, the first hookworm known to science was a parasite in the intestine of the common badger (*Meles taxus*) of Europe, described by Goeze, a German clergyman, in 1782. Goeze called the parasite "der Haarrundwurm" (the hair round worm), and gave to it the Latin name *Ascaris criniformis*. Although he placed this species in the same genus with the ordinary eelworm, *Ascaris lumbricoides*, he intimated that it represented a distinct genus. One of the anatomical characters which Goeze noticed was a membranous expansion on the tail of the male, and in this he saw two finger- or ray-like structures which he interpreted as "hooks" (see caudal rays in figs. 1, 15).

In 1789 Frœlich found a similar worm in the common fox (*Canis vulpes* or *Vulpes vulpes*) of Europe. He noticed the same membranous expansion and "two hooks with many points" on the end of the tail. On account of this character he adopted the vernacular name "Haakenwurm" (hookworm), and proposed the generic name *Uncinaria* for the new genus which he established.

It is now known that the membranous expansion is the caudal bursa, found in all members of the family Strongylidæ, while the so-called "hooks" represent the "rays" or "ribs" which support the bursa (see fig. 1). In the early part of the nineteenth century several other species of hookworms were described as parasitic in various animals, and they were united generically with the "colic worms" (strongyles) of horses.

animal with any member of this subfamily. In case the term "anchylostomiasis" is adopted, which of the many spellings should be recognized? Adopting uncinariasis relieves us of the necessity of discussing that point, and further gives to the name of the disease the same orthography in several different languages. The case at hand gives rise to the question whether it is not inadvisable to name diseases after the zoological names of the parasites, at least during the transitional stage of zoological nomenclature. As a matter of fact it is the function of the medical profession, not that of the zoological, to determine what names should be used to designate diseases, but at the present moment medical terminology is subjective.

In 1843 Dubini, of Milan, Italy, described a hookworm as parasitic in man. Besides the caudal "hooks" (i. e., the "rays") of the male, Dubini's parasite presented four hooks in the mouth. It presented further an anatomical character which is common to all hookworms, namely, the ventral surface of the anterior end grows more rapidly than the dorsal surface, so that the oral end is bent backward like a "hook," and the mouth thus occupies a dorsal position. Thus it is seen that the original character which led to the vernacular name "hookworm" was a misinterpretation; the second character of "hooks" (namely, in the mouth), which has been popularly but erroneously interpreted as responsible for the vernacular name "hookworm," is not present in all species; the hooklike curvature of the head is usually but not always distinct. I propose, however, to retain the word "hookworm" as a vernacular name.

It is not apparent that Dubini knew that Frœlich had proposed the genus *Uncinaria*, and it is probably on this account that he proposed a new genus—*Agchylostoma* by name—to contain the parasite (*Agchylostoma duodenale*) which he had found in man.

For years it was supposed that this was the only species of hookworm found in man, but in May, 1902, I showed that in America we have a distinct species, which I named *Uncinaria americana*.

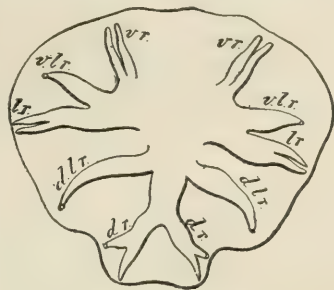


FIG. 1.—Caudal bursa of a male strongyle (*Esophagostoma dentatum*), to serve as diagram for the family: *v. r.*, ventral rays; *v. l. r.*, ventro-lateral rays; *l. r.*, lateral rays; *d. l. r.*, dorso-lateral rays; *d. r.*, dorsal rays. X 93. (After Schneider, 1866, p. 130.)

ZOOLOGICAL POSITION OF THE PARASITES.

The parasites which cause uncinariasis are worms belonging to the nematode family Strongylidæ.

Family STRONGYLIDÆ.

FAMILY DIAGNOSIS.—Nematoda: With body elongate, cylindrical, rarely filiform. Mouth is probably always provided with six papillæ, of which the four submedian are generally salient in form of nodules or conical points. In some cases the mouth is in the axis of the body; in others it is turned dorsally or ventrally, and occasionally provided with a chitinous armature. Esophagus more or less swollen in posterior portion, but without forming in adults a distinct esophageal bulb. Male provided with a caudal bursa, open or closed, entire or divided, and with one or two spicules. Female with one or two ovaries; vulva anterior or posterior of equatorial plane, in some cases near the anus. Eggs deposited during segmentation, in some cases containing embryo.

TYPE GENUS.—*Strongylus* O. F. Mueller.

The sexes are separate and the digestive tract is complete. Characteristic for the family is the presence, on the tail of the male, of an umbrella-like structure known as the caudal or "copulatory bursa,"

supported by a number of finger-like "rays," which may be compared to the ribs of an umbrella. In coitu, the male clasps the body of the female by means of this bursa.

This family is divided into subfamilies, according to the presence of certain anatomical characters. The parasites of uncinariasis are now classified in the subfamily Strongylinae,^a which, as its former name, Sclerostominae, indicated, is characterized by the presence of a hard chitinous "buccal capsule."

Subfamily STRONGYLINÆ.

SUBFAMILY DIAGNOSIS.—Strongylidae: Meromyaria; mouth with more or less complete chitinous armature. Male with two equal spicules; caudal bursa with rays, the dorsomedian and dorsolateral being united in a common base. Female with two ovaries, except in *Ollulanus*.

TYPE GENUS.—*Strongylus* Mueller.

The subfamily Strongylinae is in turn divided into a number of genera, of which we may mention here the following:

Strongylus [*Sclerostoma*]; the sclerostomes, including the colic worms of horses and the kidney worms of hogs (but not the kidney worms of dogs and man);

Syngamus, including the gape worms of chickens; and

Uncinaria, the hookworms, including the parasite of uncinariasis.

It seems very probable that hookworms will have to be divided into several different genera, for which a new subfamily will perhaps be recognized, but it is not quite clear at present just what genera will be admitted. Undoubtedly *Uncinaria* Frelich, 1789, must be adopted for one, and in this will probably be placed worms like *Uncinaria stenocephala*, possessing ventral lips but not ventral recurved teeth. It is quite possible that a second genus (*Monodontus* Molin, 1861, or *Bunostomum* Railliet, 1902) will be recognized for certain other forms, with buccal lips and with the prominent dorsomedian buccal tooth, as was proposed by Molin. The new American hookworm may be taken as type of a special subgenus *Necator* which may eventually be raised to generic rank. Hookworms with the ventral recurved buccal teeth, as seen in *Uncinaria duodenalis* and *Uncinaria canina* will probably be separated into a distinct genus, for which Dubini's name *Agchylostoma* will be available. To satisfactorily determine the points at issue will require further anatomical study of a number of different species. For the purpose of this paper it will be sufficient to call attention to these probable changes.

^a From a study of the history of the nematode genera, it is very clear that there will have to be a general revision of the technical names of this group. The original *Strongylus*, for instance, was a sclerostome, hence the names *Sclerostoma* and *Sclerostominae* will have to fall into synonymy. It is probable that *Metastrongylus* will be the correct name for the lung strongyles. *Strongylus contortus* becomes *Hæmonchus contortus*. As soon as certain remaining points of this nature are decided, Hassall and I will issue a list of nematode genera, together with their type species.

Genus UNCINARIA^a Frœlich, 1789.

GENERIC DIAGNOSIS.—Strongylinae: With anterior extremity curved dorsally; mouth round to oval, opening oblique, limited by a transparent border and followed by a chitinous buccal capsule; the dorsal portion of the capsule is shorter than the ventral, and is supported by a conical structure, the point of which sometimes extends into the cavity; at the base of the buccal capsule are found two ventral teeth; toward the inner free border the ventral wall bears on each side of the median line chitinous structures, lips (*Uncinaria*) or teeth, often recurved in shape of hooks (*Agchylostoma*); the inner dorsal wall may also bear lips or teeth. Oviparous, eggs with thin, transparent shell.

TYPE SPECIES.—*Uncinaria vulpis*^b Frœlich, 1789.

^aSYNONYMY, WITH ORIGINAL PLACE OF PUBLICATION.

- 1789: *Uncinaria* FRÆLICH<Der Naturforscher, Halle, v. 24, pp. 130-139; type, *Uncinaria vulpis* Frœlich, 1789.
- 1799: *Uncinaria* FISCHER<Arch. f. d. Physiol., Halle, v. 3, p. 99. [Apparently a misprint for *Uncinaria*.]
- 1843: *Agchylostoma* DUBINI<Annal. univers. di medic., Milano, v. 106, aprile, pp. 5-13; type, *Agchylostoma duodenale* Dubini, 1843.
- 1845: *Ancylostoma* CREPLIN<Archiv f. Naturg., Berlin, 11. J., v. 1, p. 325; for *Agchylostoma* Dubini, 1843.
- 1845: *Dochmius* DUJARDIN, Histoire naturelle d. helminthes, pp. 267, 275-279; type, *Uncinaria vulpis* Frœlich, 1789.
- 1845: *Dochmius* DUJARDIN, ibidem, p. 114. [Misprint for *Dochmius*.]
- (1846): *Ancylostoma* DELLE CHIAJE Rendicon. dell'Accad. delle Sci. Napoli, v. 5, p. 339. [Not verified.]
- 1850: *Ancylostoma* DUBINI, Entozoografia umana, pp. 102-112; for *Agchylostoma* Dubini, 1843.
- 1851: *Ancylostomum* DIESING, Systema helminthum, v. 2, p. 82; for *Agchylostoma* Dubini, 1843.
- 1851: *Ancylostomum* DIESING, Systema helminthum, v. 2, pp. 321-322; for *Agchylostoma* Dubini, 1843.
- 1861: *Monodontus* MOLIN (not *Monodonta* Lamarck, 1799), Il sottordine degli acrofalli <Mem. r. Ist. ven. di sc., lett. ed arti, Venezia, v. 9, pp. 435, 463-470; type, *M. semicircularis* Molin, 1861.
- 1861: *Dochmius* MOLIN<Ibidem, p. 471. [Misprint for *Dochmius*.]
- 1862: *Dachmius*<Veterinarian, Lond. (416), v. 35, 4. s. (92), v. 8, Aug., pp. 549-556. [Misprint for *Dochmius*.]
- 1879: *Anchylostoma* BOZZOLO<Osservatore, Torino, v. 15 (24), 17 giugno, pp. 369-370; for *Agchylostoma* Dubini, 1843.
- 1895: *Ancylostomum* STROSSICH<Boll. Soc. Adriatica di sc. nat. in Trieste, v. 16, pp. 21-25; for *Agchylostoma* Dubini, 1843.
- 18-?: "*Ancylostoma* Dubini" of various authors; for *Agchylostoma* Dubini, 1843.
- 1897: *Ancylostomum* MËLLER<Buffalo M. J., v. 36 (8), Mar., p. 573. [Misprint for *Ancylostomum*.]
- 1902: *Dochmius* LOOSS<Centrabl. f. Bakteriolog., Parasitenk. [etc.], Jena, 1 Abt., v. 31 (9), 5. Apr., Originale, p. 424. [Misprint for *Dochmius*.]
- 1902: *Uncinaria* VON LINSTOW<Zool. Centrabbl., Leipz., v. 9 (24-25), 16. Dec., p. 778. [Misprint for *Uncinaria*.]

^bThis species is probably identical with *Uncinaria melis* Frœlich, 1789; *Ascaris criniformis* Gæze, 1782, and with *Uncinaria stenocephala* (Railliet, 1884).

The anatomical character which distinguishes the genus *Uncinaria* is the dorsal curvature of the anterior extremity of the body, due to the shortness of the dorsal wall of the buccal capsule and resulting in bringing the mouth into a dorsal instead of a terminal or a ventral position.

In many medical writings this genus is named *Anchylostoma*, a word which is spelled in at least nine different ways, and the disease is spoken of as *anchylostomiasis*. This nomenclature and terminology are due to the fact that when the hookworm (*Uncinaria duodenalis*) of man was first described, in 1843, it was supposed to represent a new genus (*Agchylostoma*). As a matter of fact, however, it is generally acknowledged to be congeneric with a worm described in 1789 as *Uncinaria*. By the international "law of priority," therefore, the names *Agchylostoma*, *Anchylostoma*, etc., fall into synonymy until it can be shown that the two species are not congeneric. (See p. 14.)

In explanation to physicians it may be here stated that zoologists are obliged to deal with hundreds of thousands of technical names, and on this account they have been forced to adopt very rigid rules governing their use. Our most important rule is the "law of priority," which to us is as essential as is the "code of ethics" to the physician.

The genus *Uncinaria* contains blood-sucking worms of the worst type. They are usually not over an inch in length nor thicker than an ordinary hatpin. They are provided with a heavy armature of sharp teeth, by means of which they pierce the intestinal mucosa of their host. They have also an unusually strong muscular esophagus, which serves as a pump during the act of sucking blood. An important point, from the medical aspect of the parasites, is that they do not remain fastened to one spot in the bowels, but suck first at one spot and then at another. Thus the patient loses blood directly to the parasites, and also, by numerous minute hemorrhages, into the intestine. It is probably this latter factor which occasionally gives to the stools of patients that peculiar reddish-brown tinge, and also their occasional bloody appearance.

The injury to the intestinal wall does not stop with the bite. The wound forms an excellent point of attack for bacteria, and the intestinal wall becomes thickened, thus losing, to a greater or lesser degree, the ability properly to perform its function. Not only does the patient lose blood, but his power of assimilation is impaired, and the supply of blood-forming material is thus in part cut off. Some authors also claim that the parasites produce a poison which acts upon the system, a view which is very strongly supported by certain clinical facts.

It was stated above that hookworms are found in various animals. Now, the general rule may be laid down that where these worms are present trouble may be expected.

Uncinaria americana and *Agchylostoma duodenale* cause in man the disease variously known as uncinariasis, uncinariosis, anchylostomiasis, tunnel disease, miners' anemia, brickmakers' anemia, mountain anemia, etc.

Agchylostoma caninum [*Uncinaria canina*^a] causes a similar disease in dogs, resulting, in some parts of the country, in a death rate of from 25 to 40 per cent of the pups born. Uncinariasis in dogs is exceedingly common in Washington, D. C. "Typhoid" in cats is attributed to this parasite.

Instructors in medical colleges who wish to demonstrate hookworms and their eggs to the students will find *A. caninum* of dogs an excellent substitute for *Agchylostoma duodenale* of man in case the latter species can not be obtained.

Uncinaria stenocephala occurs in dogs, foxes, and allied animals, and is causing considerable trouble in the blue fox (*Vulpes lagopus*) industry.

Uncinaria trigonocephala^b is found in sheep and produces a serious anemia. This parasite has been met in Victoria and Calhoun counties, Tex., where, in conjunction with the twisted wireworm (*Hæmonchus contortus*^c), it has caused the death of from 25 to 50 per cent of certain flocks.

Uncinaria radiata^d is found in cattle, producing trouble just below the stomach. The writer has collected this parasite in Dewitt, Gonzales, Victoria, and Calhoun counties, Texas, and has seen specimens from Florida collected by Dr. C. F. Dawson.

Uncinaria Lucasi was found several years ago in the seal pups of Alaska by Mr. Lucas, after whom the worm has been named. It is responsible for about 17 per cent of the deaths of the pups.

Still other species of hookworms are reported for other animals.

None of the species from animals mentioned above is known to affect man, nor has either *Uncinaria americana* or *Agchylostoma duodenale* of man been satisfactorily demonstrated to occur normally in other hosts than man.

^aThis is *Uncinaria canina* (Ercolani 1859) Railliet, 1900, a parasite of canines and felines, which is usually known as *Uncinaria trigonocephala* (Rudolphi, 1809) Railliet, 1885 [not *Uncinaria trigonocephala* (Rudolphi, 1809) Railliet, 1900]. If *Uncinaria* and *Agchylostoma* are recognized as distinct, *U. canina* should be placed in the same genus as *U. duodenalis*. I have not yet tested the correctness of the specific name *canina* for this form, but it is here accepted on authority of Railliet.

^bThis is *Uncinaria trigonocephala* (Rudolphi, 1809) Railliet, 1900 [not "*U. trigonocephala* Rudolphi, 1809"] Railliet, 1885]. Both Railliet and I have recently examined Rudolphi's original material, and it is unquestionably identical with *U. cernua* (Creplin, 1829) of sheep. This species is closely related to *U. americana*.

^c*Strongylus contortus* Rudolphi.

^d*Bunostomum phlebotomum* Railliet.

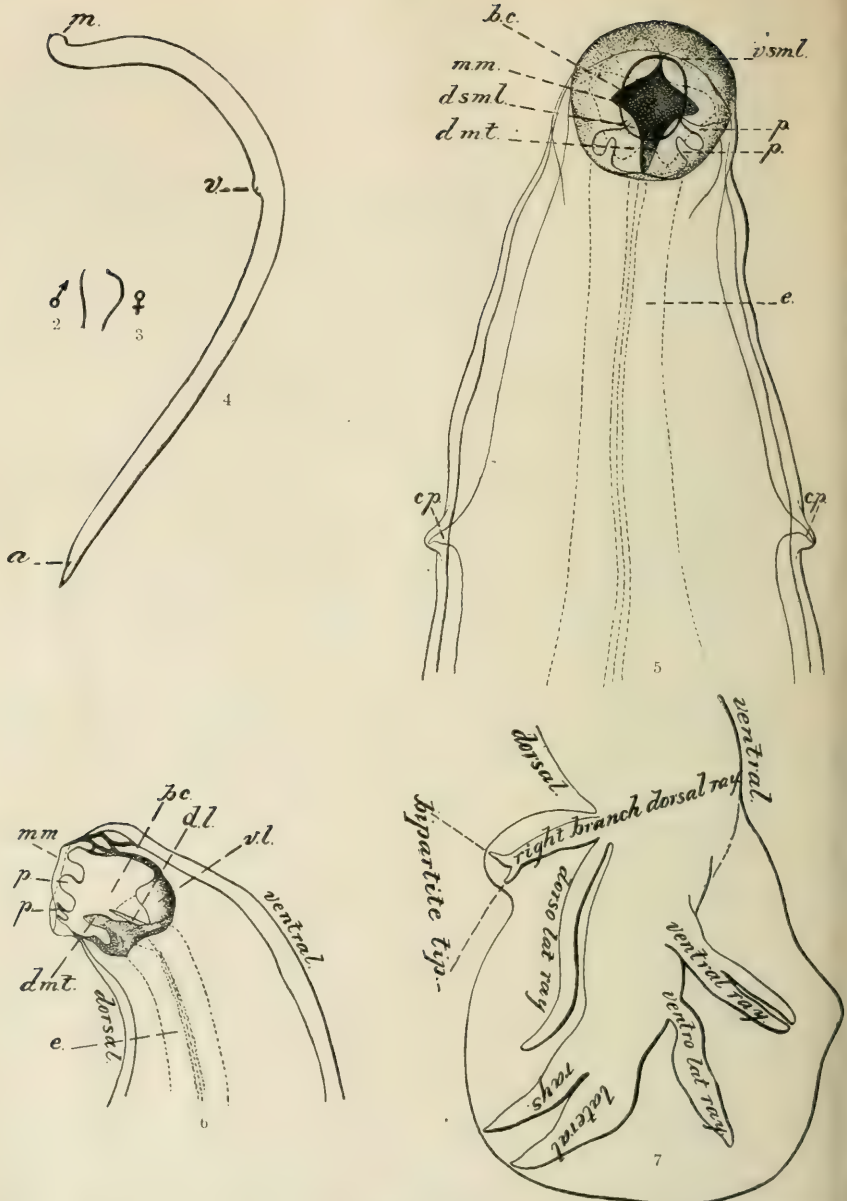


FIG. 2.—New World male hookworm (*Uncinaria americana*). Natural size. (After Stiles, 1902b, p. 190, fig. 120.)

FIG. 3.—New World female hookworm (*Uncinaria americana*). Natural size. (After Stiles, 1902b, p. 190, fig. 121.)

FIG. 4.—The same, enlarged to show the position of the anus (*a*) and the vulva (*v*). After Stiles, 1902b, p. 190, fig. 122.)

FIG. 5.—Dorsal view of anterior end of New World hookworm (*Uncinaria americana*); *b. c.*, buccal cavity; *c. p.*, cervical papillae; *d. m. t.*, dorsal median tooth, projecting prominently into the buccal cavity; *d. sm. l.*, small dorsal semilunar lip; *e.*, esophagus; *m. m.*, margin of mouth, the prominent oval opening seen upon high focus; *p. p.*, papillae; *v. sm. l.*, large ventral semilunar lips homologous with the ventral hooks of *A. duodenale*. Greatly enlarged. (After Stiles, 1902b, p. 190, fig. 123.)

FIG. 6.—Lateral view of anterior end of New World hookworm (*Uncinaria americana*); *b. c.*, buccal cavity; *d. m. t.*, dorsal median tooth, projecting prominently into buccal cavity; *e.*, esophagus; *m. m.*, margin of mouth; *p. p.*, papillae; *d. l.*, dorsal lancet; *v. l.*, ventral lancets at the base of the buccal cavity. Greatly enlarged. (After Stiles, 1902b, p. 190, fig. 124.)

FIG. 7.—Lateral view of caudal bursa of the New World male hookworm (*Uncinaria americana*), showing the arrangement of the rays. Note the short dorsal lobe. Greatly enlarged. (After Stiles, 1902b, p. 190, fig. 125.)

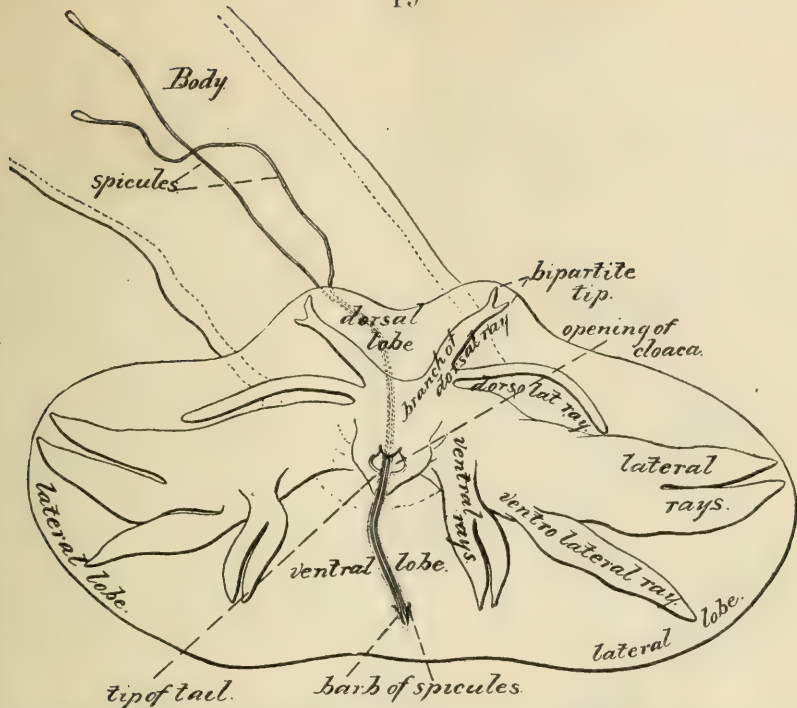


FIG. 8.—The caudal end of the New World male hookworm (*Uncinaria americana*). The bursa is spread out to show the arrangement of the rays. Note the short dorsal lobe which is subdivided, forming two lobes; note also the indistinct ventral lobe connecting the two lateral lobes. The dorsal lobe is thrown back over the body. [Additional material shows that the "barb" or tip of the spicules as drawn is not quite correct.] Greatly enlarged. (After Stiles, 1902b, p. 191, fig. 126.)

[**UNCINARIA** Frælich, 1789, *sensu stricto*.]

DIAGNOSIS.—*Uncinaria* s. l. with buccal lips.

TYPE SPECIES.—*Uncinaria vulpis* Frælich.

The New World hookworm—**UNCINARIA AMERICANA**^a Stiles, 1902—of man.

(Figures 2 to 9.)

SPECIFIC DIAGNOSIS.—*Uncinaria*: Body cylindrical, somewhat attenuated anteriorly. Buccal capsule with a ventral pair of prominent semilunar plates or lips, similar to *U. stenocephala*, and a dorsal pair of slightly developed lips of the same nature; dorsal conical median tooth projects prominently into the buccal cavity, similar to *Monodontus*; one pair of dorsal and one pair of ventral submedian lancets deep in buccal capsule. Male, 7 to 9 mm. long; caudal bursa with short dorso-median lobe, which often appears as if it were divided into two lobes, and with prominent lateral lobes united ventrally by an indistinct ventral lobe; for rays, see figures 7-8; common base of dorsal and dorso-lateral rays very short; dorsal ray divided to its base, its two branches being prominently divergent and their tips being bipartite; spicules long and slender. Female, 9 to 11 mm. long; vulva in anterior half of body, but near equator. Eggs, ellipsoid, 64 to 76 μ long by 36 to 40 μ broad, in some cases partially segmented in utero, in other (rare) cases containing a fully developed embryo when oviposited.

HABITAT.—Small intestine of man (*Homo sapiens*) in America (determined to date, for Virginia, North and South Carolina, Georgia, Florida, Alabama, Texas, Porto Rico, Cuba, and Brazil).

TYPE SPECIMENS.—No. 3310, B. A. I., U. S. Dept. Agric.

^aSYNONYMY WITH ORIGINAL PLACE OF PUBLICATION.

1902: *Uncinaria americana* STILES < Am. Med., Phila., v. 3 (19), May 10, pp. 777-778.

1902: *Uncinaria americana* (Stiles) VON LINSTOW < Zool. Centralbl., Leipz., v. 9 (24-25), 16. Dec., p. 778. [Misprint.]

LIFE HISTORY OF *UNCINARIA AMERICANA*.

The life history of the American hookworm has not yet been determined in detail, but there is no reason for assuming that it will differ radically from that of *Agchylostoma duodenale* (see p. 24.)

In my first description of the worm I stated that the egg in the uterus may occasionally contain an embryo. Since making this observation on the females sent to me by Dr. Allen J. Smith I have examined hundreds of fresh eggs, but have not found any containing developed embryos. The question may therefore legitimately arise whether the females originally examined were not exposed to the air for some time before they were preserved, thus making the development of the eggs possible. If the embryo does develop in the uterus, as indicated by some of Dr. Allen J. Smith's material, such an occurrence is undoubtedly rare.



FIG. 9.—Four eggs of the New World hookworm, *Uncinaria americana*, in the 1, 2, and 4 cell stages. The egg showing 3 cells is a lateral view of a 4-cell stage. These eggs are found in the feces of patients and give a positive diagnosis of infection. Greatly enlarged. (After Stiles, 1902b, p. 192, fig. 127.)

DEVELOPMENT OUTSIDE THE BODY.

Segmentation.—In feces exposed to a September, October, or early November temperature of the Carolinas, Georgia, and Florida, the embryo develops in the egg (fig. 9) in about one day's time. In some instances the embryo develops in less than 24 hours. It is a common occurrence to find feces 24 hours old containing free embryos.

The conditions under which the trip was made were not favorable to exact observation in regard to temperature, moisture, etc. It was, however, possible to find worms in their first ecdysis about 2 to 3 days after hatching, and worms in the second ecdysis about 7 to 9 days after hatching. These observations were made under most unfavorable circumstances, when careful measurements, drawings, etc., were excluded, hence they should be repeated.

DEVELOPMENT INSIDE THE BODY.

Experimental infections during the trip were, of course, impossible.

[AGCHYLOSTOMA "Dubini, 1843.]

DIAGNOSIS.—*Uncinaria*: Provided with ventral recurved teeth.

TYPE SPECIES.—*Agchylostoma duodenale* Dubini, 1843.

The Old World hookworm—**AGCHYLOSTOMA DUODENALE** ^b Dubini, 1843, or **UNCINARIA DUODENALIS** (Dubini) Railliet, 1885—of man.

(Figures 10 to 41.)

SPECIFIC DIAGNOSIS.—*Agchylostoma*: Body cylindrical, somewhat attenuated anteriorly. Buccal cavity with two pairs of ventral teeth curved like hooks, and one pair of dorsal teeth directed forward; dorsal rib not projecting into the cavity. Male, 8 to 11 mm. long; caudal bursa with dorso-median lobe, and prominent lateral lobes united by a ventral lobe; for rays, see fig. 14; dorsal ray divides at a point two-thirds its length from its base, each branch being tridigitate; spicules long and slender. Female, 10 to 18 mm. long; vulva at or near posterior third of body. Eggs, ellipsoid, 52 to 60 μ by 32 μ , laid in segmentation. Development direct without intermediate host.

^aThere are numerous ways of spelling this word (see p. 15), more than one with more or less philological authority. Under these circumstances I adopt the original orthography, despite the fact that it is not philologically correct. By this action I do not intend to necessarily reject the ruling covered by the International Code, but from practical experience I find it impracticable to carry out said rule in reference to the emendation of names until the question of homonyms is decided.

^bSYNONYMY, WITH ORIGINAL PLACE OF PUBLICATION.

1843: *Agchylostoma duodenale* DUBINI <Ann. univer. di med., Milano, v. 106, aprile, pp. 5-13, pl. 1, figs. 1-5; pl. 2, figs. 1-3.

1845: *Ancylostoma duodenale* (Dubini) CREPLIN <Arch. f. Naturg., Berl., 11. J., v. 1, p. 325.

(1846): *Ancylostoma duodenale* (Dubini) DELLE CHIAJE <Rendicon. dell' Accad. delle sci., Napoli, v. 5, p. 339. [Not verified.]

1850: *Ancylostoma duodenale* (Dubini) DUBINI, Entozoografia umana, pp. 103-112.

1851: *Ancylostomum duodenale* (Dubini) DIESING, Systema helminthum, v. 2, p. 322.

?(1851): *Strongylus quadridentatus* SIEBOLD <Naturforsch. Versamml. z. Gotha. [Not verified.]

1861: *Dochmius anchylostomum* MOLIN, Il sottordine degli acrofalli <Mem. r. Ist. ven. di sc., lett. ed arti, Venezia, v. 9, pp. 485-487.

1864: *Sclerostoma duodenale* (Dubini) COBBOLD, Entozoa, pp. 361-362, fig. 77.

1866: *Strongylus duodenalis* (Dubini) SCHNEIDER, Monographie der Nematoden, Berl., pp. 139-140, 1 fig., pl. 9, fig. 3.

1866: "*Ancylostomum duodenale* Dubini" of WHITE <Boston M. & S. J., v. 75 (21), Dec. 20, p. 427. [Misprint for *duodenale*.]

1876: *Dochmius duodenalis* (Dubini) LEUCKART, Die menschlichen Parasiten, v. 2 (3), pp. 410-460, figs. 235-239, 241-247, 249.

1879: *Ancylostoma duodenale* (Dubini) BOZZOLO, Osservatore, Torino, v. 15 (24), 17 giugno, pp. 369-370.

1881: *Dochmius duodenalis* - Rev. méd. de la Suisse Rom., Genève, v. 1 (3), 15 mars, p. 190.

1885: *Uncinaria duodenalis* (Dubini) RAILLIET, Éléments de zool. méd. et agric., Par., pp. 357-359, figs. 245-248.

1897: *Ancylostomum duodenale* (Dubini) MÖHLAU <Buffalo M. J., v. 36 (8), Mar., pp. 573-579. [Misprint for *Ancylostomum duodenale*.]

Ancylostoma duodenale and *Ancylostomum duodenale* of various authors.

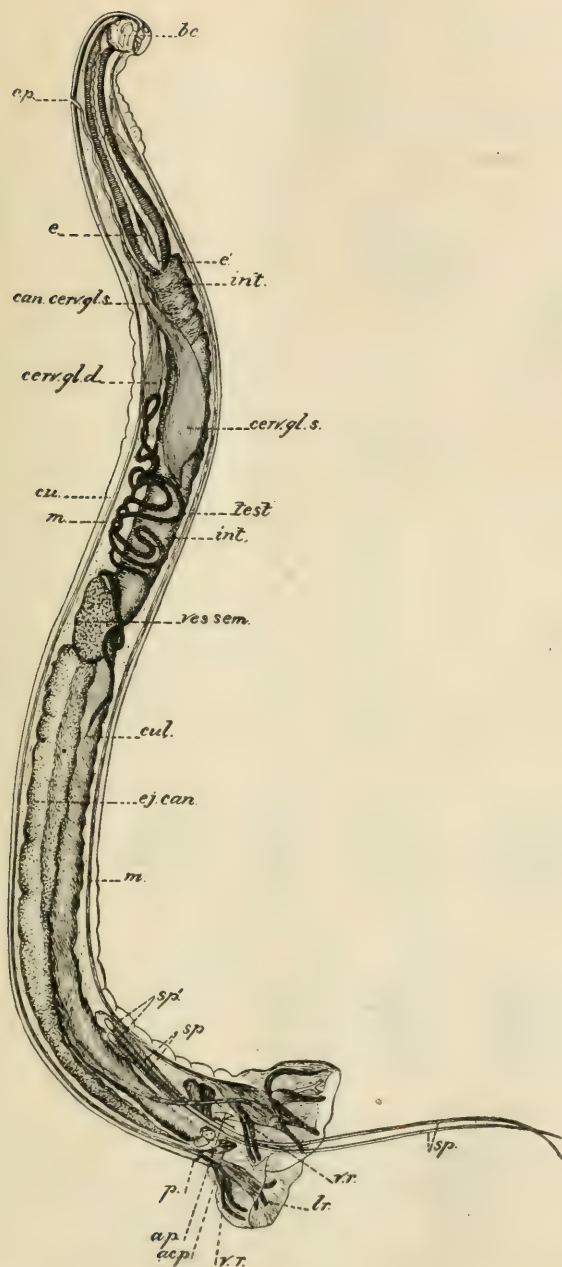


FIG. 15.—Male hookworm (*Agchylostoma duodenale*) of man. *ac. p.*, accessory piece of spicules; *a. p.*, "anal papilla;" *b. c.*, buccal capsule; *can. cerv. gl. s.*, canal of left cervical gland; *cerv. gl. d.*, right cervical gland; *cerv. gl. s.*, left cervical gland; *cu.*, cuticle; *cul.*, cul de sac of testicular tube; *e.*, esophagus; *e'*, posterior end of esophagus; *e. p.*, ventromedian excretory pore; *ej. can.*, ejaculatory canal; *int.*, intestine; *l. r.*, lateral ray of bursa; *m.*, muscular layer; *p.*, lateral praecaudal papilla; *sp.*, spicules; *sp'*, anterior end of spicules; *test.*, testicular tube; *res. sem.*, vesicula seminalis; *r. r.*, ventral rays of bursa. Greatly enlarged. (After Schulthess [copied from Blanchard, 1888a, p. 755, fig. 370].)

LIFE HISTORY OF AGCHYLOSTOMA DUODENALE OR UNCINARIA
DUODENALIS.

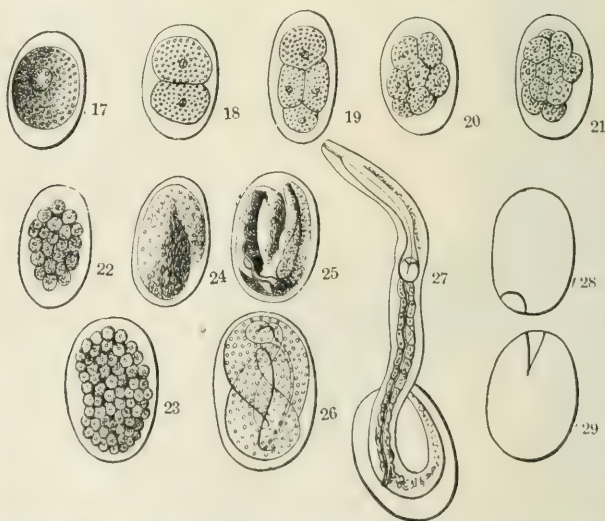
The eggs (fig. 16) are laid in the intestinal tract of the patient by the female worms and are discharged in the feces, either unsegmented or during the early stages of segmentation. They will not develop into adult worms in the intestine, but must first pass out of the body. Thus, for every adult hookworm present in the bowels a separate germ must enter the body.



FIG. 16.—Eggs of Old World hookworms (*Agchylostoma duodenale*) as found in the stools. Greatly enlarged. (After Stiles, 1902b, p. 193, fig. 128.)

The egg has a thin shell, which is an indication of a simple life cycle. A short time after escaping in the feces—the time varying according to temperature, moisture, and position in the feces—each egg develops (figs. 17–27) a minute embryo, which is known as a rhabditiform embryo (fig. 27). This name is given to it because of its resemblance to

worms of the genus *Rhabditis*. Characteristic for this stage is the rhabditiform esophagus, which is entirely different from the esophagus



FIGS 17-29.—Embryology of the Old World hookworm (*Agchylostoma duodenale*) of man; 17-23, segmentation of the egg; 24-26, the embryo; 27, a rhabditiform embryo escaping from its eggshell; 28-29, empty eggshells. Greatly enlarged. (After Perroncito, 1882, p. 342, fig. 142.)

of the adult hookworm. This embryonal esophagus is more or less bottle shaped, and consists of three parts—an anterior elongated

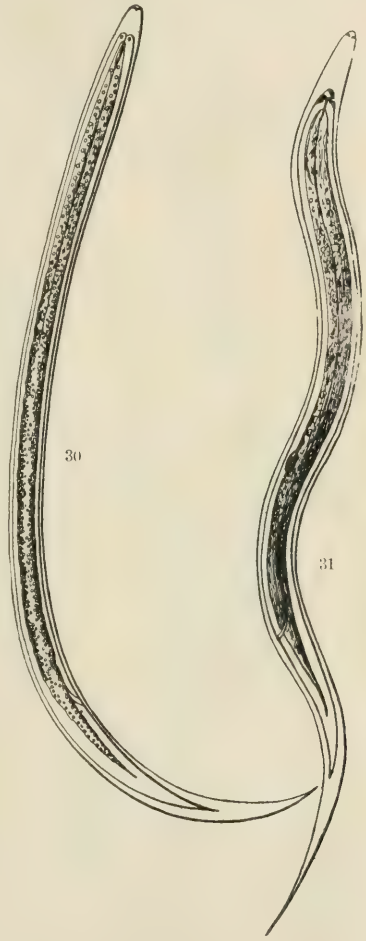
swollen portion, followed by a thin middle portion, the latter being followed by a more or less globular esophageal bulb which possesses a triradiate chitinous armature. This kind of esophagus is common to the early stage of all members of the family Strongylidae and also to numerous other free-living or parasitic nematodes. It is evidently a worm with an esophagus of this sort which was recently found in the earth taken from the New York tunnel excavations, and upon which was based the report that uncinariasis was present.

The embryo of the hookworm lives in water or moist ground. In its evolution the worm casts its skin four times, thus passing through five stages, and changes its structure so as to assume more and more the characters of the adult. During these changes the sexes become differentiated. Some of these changes occur in water or moist ground, and the rest after infection takes place.

DEVELOPMENT OUTSIDE THE BODY.

Segmentation.—The eggs develop best in the unaltered fecal matter, especially when this is well formed; not so well when it is more fluid in character. The addition of water retards the development, and if considerable water is added the eggs perish. Air is necessary to development, and the eggs nearer the surface of the feces segment more rapidly than those in the center. At a temperature of about 27° C. the embryo may form and escape from the shell in twenty-four hours. Lower temperatures retard development, so that at 21° or 22° C. the embryo may not escape for from thirty-six to forty hours; 1° C. kills the eggs in twenty-four to forty-eight hours, so that freezing weather may be looked upon as disinfecting areas exposed to the cold.

Embryo.—Upon escaping from the shell, the embryo (fig. 27) meas-



FIGS. 30-31.—Two larvæ of the Old World hookworm at the end of the second stage ("encysted larvæ"), representing the young worms retracted from their skin. (After Perroncito, 1882, p. 350, figs. 148 a-b.)

ures 0.3 mm. in length; the anterior end is blunt, the tail long and pointed; 6 points are visible around the mouth, and these develop later into the papillae; the buccal cavity is $10\ \mu$ long, $1.4\ \mu$ in diameter, and possesses a highly refractive chitinous membrane; the anus is $50\ \mu$ from the tip of the tail; excretory pore $50\ \mu$ from anterior end; $160\ \mu$ from anterior end is seen the primordium of the genital system.

In this stage the embryo takes food and grows. About the second

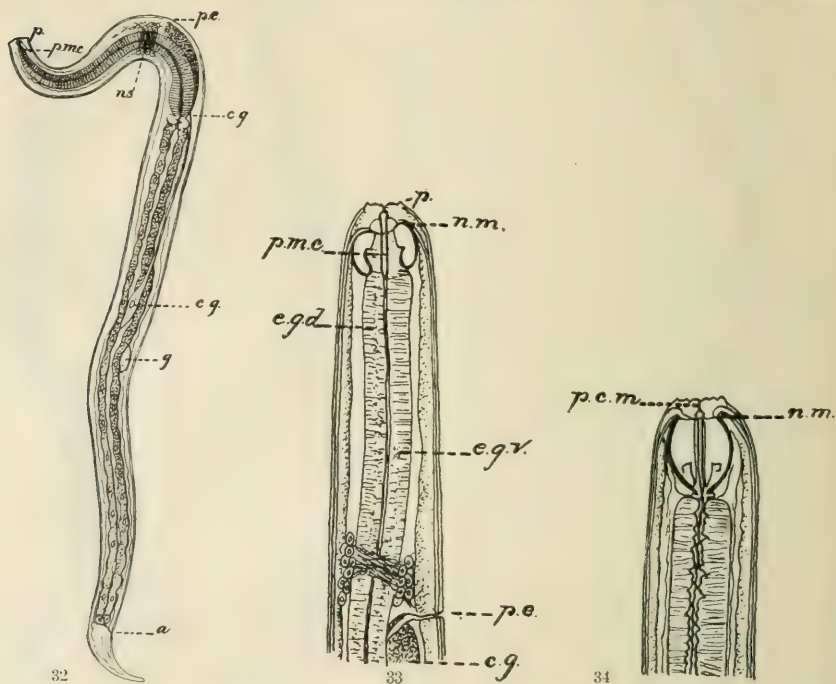


FIG. 32.—A young hookworm (*Agchylostoma duodenale*) of man, without buccal capsule, four days after infection; *a*, anus; *c. g.*, cervical gland; *g*, primordium of genital organs; *n. s.*, nervous system; *p.*, papillae on head; *p. e.*, excretory pore; *p. m. c.*, primary mouth cavity. X about 190 times. (After Looss, 1897, p. 919, fig. 1.)

FIG. 33.—Anterior end of a young hookworm (*Agchylostoma duodenale*) during formation of provisional buccal capsule; *c. g.*, cervical gland; *c. g. d.*, dorsal esophageal gland; *c. g. v.*, ventral esophageal gland; *n. m.*, new mouth; *p.*, papillae on head; *p. e.*, excretory pore; *p. m. c.*, primary mouth cavity. X 578. (After Looss, 1897, p. 920, fig. 2.)

FIG. 34.—Head of larval hookworm (*Agchylostoma duodenale*) before entering fourth stage, five or six days after infection; *n. m.*, new mouth; *p. c. m.*, primary mouth cavity, which extends through the provisional buccal capsule and continues as lumen of the esophagus. X 578. (After Looss, 1897, p. 921, fig. 3.)

or third day the embryo casts its first skin, but does not change its organization. After about four or five days (at 27°C .) it measures $480\ \mu$ long by $30\ \mu$ in diameter.

Second stage.—After the fifth day the young worms begin to show signs of a second ecdysis, at the same time undergoing certain other changes. Three minute lips, each with two very delicate papillae, appear under the skin at the anterior end; the brightly refringent cutic-

ular lining of the buccal cavity and the chitinous teeth of the esophageal bulb disappear; the esophagus elongates, becomes thinner, and its three divisions become less distinct; the tail becomes slightly shorter and more blunt; the anus lies $90\ \mu$ from the tip of the tail. The organ-

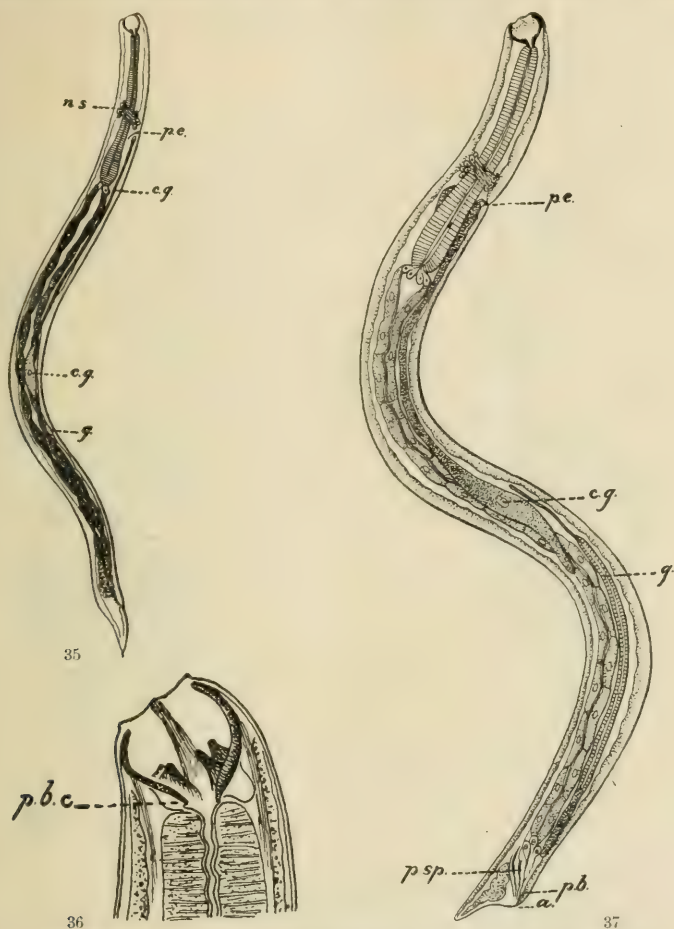


FIG. 35.—Young hookworm (*Agchylostoma duodenale*) in fourth stage, with provisional buccal capsule: c. g., cervical gland; g., primordium of genital organs; n. s., nervous system; p. e., excretory pore. X 105. (After Looss, 1897, p. 921, fig. 4.)

FIG. 36.—Provisional buccal capsule (fourth stage) of a larval hookworm (*Agchylostoma duodenale*), about nine days after infection: p. b. c., primordium of definite buccal capsule. X about 420. (After Looss, 1897, p. 921, fig. 5.)

FIG. 37.—Young male hookworm (*Agchylostoma duodenale*), nine days after infection. a., anus; c. g., cervical gland; g., genital tract; p. b., primordium of bursa; p. e., excretory canal; p. sp., primordium of spicules. X about 105. (After Looss, 1897, p. 922, fig. 6.)

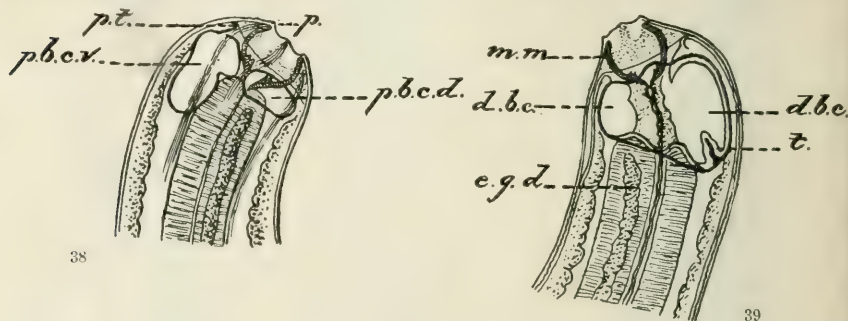
ism becomes more motile, and contracts from its outer skin, thus forming the stage (figs. 30–31) which has been described as an “encystation,” but which in reality is simply a second ecdysis. This is the infecting stage of the hookworm, and ends the development so far as the free life is concerned. No more food is taken. In some cases, however,

the worm escapes from the surrounding cast skin. While water is more or less injurious to the egg and the first stage, the infecting "encysted" stage exists well in this medium, and Looss (1897) succeeded in keeping these worms alive for thirty days in water. Upon drying up the larvæ die, so that the view that the worms exist in dust and are carried around in the air, thus leading to infection, is not well founded (see p. 30).

DEVELOPMENT INSIDE THE BODY.

Upon being swallowed these young worms undergo further ecdyses, changing their internal organization at the same time. We may recognize, with Looss, a third stage, without buccal capsule (fig. 32); a fourth stage, with a provisional buccal capsule (fig. 35); finally, a fifth stage, with the definite buccal capsule, corresponding to the adult form.

Third stage (without buccal capsule, fig. 32).—During their free life the larvæ may attain 0.65 to 0.7 mm. in length by 25 to 27 μ in diam-



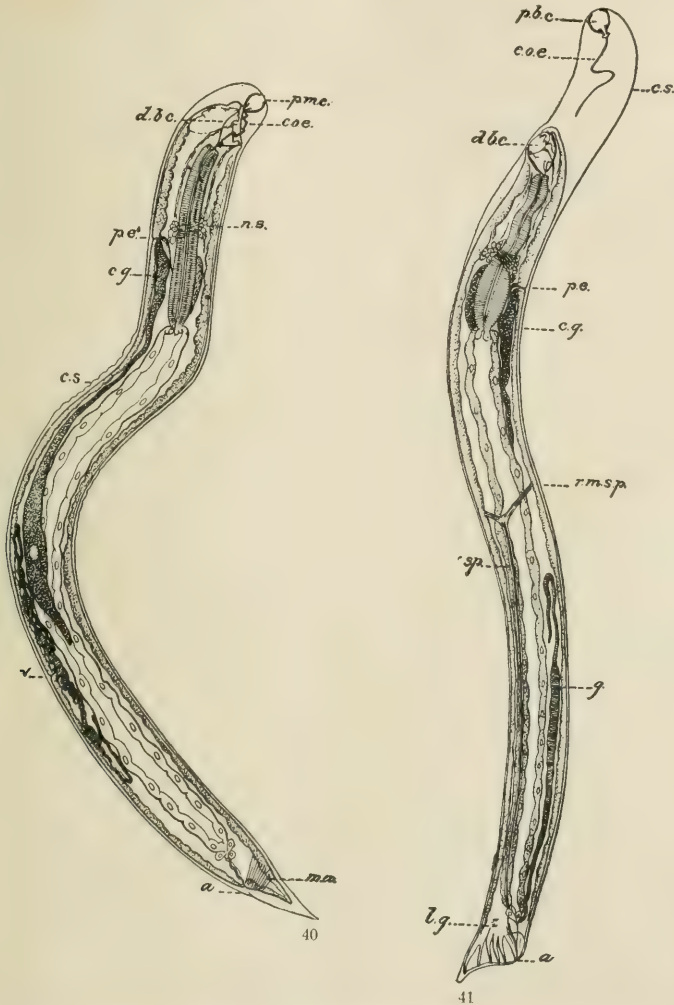
FIGS. 38-39.—Development of definite buccal capsule (38, on twelfth day after infection; 39, one or two days later): *d. b. c.*, definite buccal capsule; *e. g. d.*, dorsal esophageal gland; *m. m.*, margin of definite mouth; *p.*, papillæ on head; *p. b. c. d.*, *p. b. c. v.*, dorsal and ventral primordia of the definite buccal capsule; *p. t.*, primordium of ventral tooth; *t.*, ventral tooth; the new cuticle can be distinguished under the old. X 190. (After Looss, 1897, p. 923, figs. 7-8.)

eter (at the end of the esophagus). The esophagus is 160 μ long, and its three divisions may still be distinguished. The intestine is composed of about 15 rows of two cells each.

Fifteen hours after infection of dogs the worms have passed below the stomach. They now begin to feed, but their growth is comparatively slow. After about five days they begin to show signs of a third ecdysis, which continues until about the seventh day. During this period important changes take place, especially at the anterior end, and result in the formation of the provisional buccal capsule.

Fourth stage (with provisional buccal capsule, fig. 35).—This is the fourth larval stage, namely, the stage after the third ecdysis. The worms have not increased notably in length, but certain organs are advanced in development, and the esophagus no longer shows its former three divisions. The worms measure about 0.66 mm. long by 25 μ in diameter, the latter being nearly uniform for a greater part of the

length (fig. 35). The provisional buccal capsule attains $40\ \mu$ in diameter, and the mouth is bent slightly dorsad. Two pairs of teeth are visible at the base of the capsule—one pair situated dorsally, the other ventrally. During this stage the animal increases in length and thick-



FIGS. 40-41.—Male and female hookworms (*Agchylostoma duodenale*) during the fourth casting of skin, 14 to 15 days after infection: a., anus; c. g., cervical gland; c. o. e., cuticle of old esophagus; c. s., cast skin; d. b. c., definite buccal capsule; g., genital organs; l. g., large ganglion, supplying the rays of the bursa; m. a., anal muscle; n. c. gl., nucleus of cervical gland; p. e., excretory pore; p. b. c., provisional buccal capsule; r. m. sp., retractor muscles of spicules; sp., spicules; v., vulva. X 42. (After Looss, 1897, p. 924, figs. 9-10.)

ness, the inner organs become better developed, the sexes become differentiated, and the definite buccal capsule forms at the anterior end. With these changes the parasite prepares for its last—namely, a fourth—ecdysis, which occurs about fourteen to fifteen days after infection.

Fifth stage (with definite buccal capsule).—The worm is now about 1.9 (male) to 2 mm. (female) long, 12 to 14 μ in diameter—very much smaller than the adult forms. It is estimated that the parasites require about four to five or six weeks from the time of infection to become mature.

SOURCE OF INFECTION OF UNCINARIASIS.

The worms may be swallowed in contaminated food or in drinking water during or after the second ecdysis. Persons handling dirt are especially apt to get the microscopic worms on their hands, and it is an easy matter to transfer them to the mouth, either directly by biting the finger nails or sucking the fingers, or indirectly with food. In prevention, therefore, careful personal habits and pure drinking water are indicated.

Some writers state that the young stages are scattered in the air by the wind and in a dry state, the inference being that they may then be breathed in or may contaminate food. While not caring to go to the extreme of stating that such a method of dissemination or infection is impossible, my own observations on this class of parasites do not lead me to attach any importance to aërial infection. As a rule, drying-out results in a high mortality among nematode larvæ, embryos, and eggs, while moisture, on the other hand, is necessary for their existence. Now, uncinariasis is not so common as to fill the air with dried larvæ, and the chances of inhaling the latter appear to be almost infinitesimally small. Since the worms do not increase in number in the intestinal tract, we should therefore expect (in case aërial infection were common) to find rather few cases of severe infection, but a more or less uniform light infection of nearly all persons or animals inhabiting an infected area, since all are breathing the same air. Further, as adults breathe more air than children we should expect the former to present the cases of heaviest infection. We should also expect to find the disease more general in dry years than in wet seasons. Such, however, does not appear to be the case. Cases of infection vary greatly in intensity, and the losses from nematode diseases in sheep are much less in dry years and in dry localities than in wet seasons. As a matter of fact, few factors can be conceived of which would probably result in killing more germs of the disease than would dry winds.

In preventing uncinariasis and nematode diseases in general among live stock, systematic draining and burning of pastures are strongly advocated.

Looss (1898, 1901) recently suggested that the larvæ may enter the human body by way of the skin and then pass through the body to the intestine. Startling as this view is, Looss (see Sandwith, 1902) has recently demonstrated the correctness of it. (See p. 59.)

BRIEF REVIEW OF UNCINARIASIS.

Uncinariasis is by no means a new disease. According to Sandwith (1894), a medical papyrus, written about three thousand four hundred and fifty years ago, embraced in an encyclopedic form the knowledge at that time of Egyptian teachers. This oldest of all books among medical works (Eber's papyrus) came into the hands of Professor Ebers at Thebes, in 1873, and has recently been translated into German. Dr. Joachim (1890) and Scheuthauer (1881) agree that anemia, due to hookworms (*Ancylostoma duodenale*), was well known to physicians of those days under the name of "AAA" and "UHA." The papyrus describes accurately among the symptoms, "heart weakness, palpitation, stabbing cardiac pains, constipation, edema of the legs, a weight in the body pressing heavily, and other digestive troubles." It further prescribes a remedy for a patient who has in his body worms, which are produced by the "AAA" disease, and possibly it is the hookworms which are referred to.

Within modern times this special form of anemia was described in Brazil by Piso in 1648; Labat (1742 or 1748) observed it in Guadeloupe, Chevalier (1752) in St. Domingo, Dazille and Bason (1776) in the Antilles, and Edwards (1790 or 1793) in Jamaica. In Europe, the disease was first noted among the miners of Anzin in 1802.

Not until 1843 was the parasite (*Ancylostoma duodenale*) described, when Dubini of Milan published an account of it. Later it was reported from Egypt, Germany, France, India, Ceylon, Japan, Australia, and elsewhere, and to it was attributed a certain widespread anemia of brickmakers, tunnelers (St. Gothard tunnel anemia), and miners.

Zinn and Jacoby (1898), who have compiled 464 bibliographic references to the disease, give two charts showing its distribution at the time their paper was published.

In studying the maps, it will be well to recall that at the time they were printed nothing was known regarding the relations of uncinariasis to the soil (see p. 47), hence, the areas which are given as infected are probably much greater than the actual extent of the infested territory; further, the maps would indicate that they have registered the places in which hookworm disease has been diagnosed, and not necessarily the areas in which hookworm infection occurs.

In connection with their references to the United States, they simply mention Georgia, Alabama, and Louisiana, saying that there is little to report upon this subject for these localities.

BRIEF REVIEW OF UNCINARIASIS IN THE UNITED STATES.

In order to understand the American publications on this disease, it must be stated that much of the so-called "dirt-eating," "pica," "cachexia africana," antebellum "negro consumption," "mal d'estomac," "malnutrition," and "malarial anemia," described for the Southern Atlantic States, is in reality due to uncinariasis.

The earliest reference which seems quite positively to refer to this disease in this country, so far as I have yet found, is an article by Dr. Pitt (1808, pp. 340-341), who says that along the Roanoke River, North Carolina, malacia or dirt-eating "prevails mostly among the poor white people and negroes, and originates, in my opinion, from a deficiency of nourishment." Chabert's (1821) description of the conditions of the slaves of Louisiana, which he attributed to dirt-eating, Jordan's (1832, of Person County, N. C.) account of "cachexia africana, or negro consumption," Cotting's (1836) account of the dirt-eating in Richmond County, Ga., Little's (1845) description of the dirt-eaters of Florida, Le Conte's (1845) account of the dirt-eating in the pine barrens of Georgia, Duncan's (1850) record of dirt-eaters in St. Mary's Parish, La., all apply so well to the uncinariasis I studied in some of the same States that I have no hesitation in assuming that many, if not all, of the cases were due to infection with *Uncinaria*. Lethermann (Florida), Lyell (Georgia and Alabama), and Heusinger and Geddings (South Carolina) are said to have published on similar conditions in the South, but not being able to trace their articles, I am unfortunately unable to give them full credit for whatever views they may have advanced.

Blickhahn (1893a) seems to have been the first physician to recognize as such and to publish a case of uncinariasis for this country. The patient was a German brickmaker who had been in the United States seventeen months, and Blickhahn believes the infection took place in Germany. It is true that Herff (1894) records a case of supposed uncinariasis observed in Texas in 1864, and Allen J. Smith (published by Schaefer, 1901) found *Uncinaria* eggs in feces of man in Texas in 1893, but these publications are antedated^a by Blickhahn's article; hence Blickhahn has priority of discovery. It is, however, interesting to note that Blickhahn's case, being in a German, was probably caused by the Old World parasite, *Agchylostoma duodenale*, while the cases of Herff and Allen J. Smith were in all probability the first endemic cases recognized. Herff did not appear altogether certain regarding his diagnosis, but his short account of the worm indicates that the interpretation is correct.

^a In all zoologic matters neither priority of observation nor priority of presentation before a scientific society avails to give priority of discovery. By international agreement, and by custom extending back a century and a half, zoologists recognize only actual publication as governing a question of this sort.

Möhlau (1896) reported five cases for Buffalo, N. Y., which were supposed to be due to the Old World parasite (*Agchylostoma duodenale*). Gray (1901) recorded two cases for Richmond, Va., contracted elsewhere in the same State, which he states positively (personal conversation) were due to *Agchylostoma duodenale*, and Tebault (1899) recorded a case of uncinariasis in a boy of German descent in New Orleans.

To one of my former pupils, Dr. Bailey K. Ashford (1900), of the U. S. Army, is unquestionably due the credit of having first seriously directed the attention of American physicians and zoologists to this disease.^a Ashford in fact found this malady very common in Porto Rico, and although he erroneously considered the parasite to be identical with the Old World species, his clinical observations placed the American medical profession on its guard for cases which might occur in returning American troops.

In 1901 there was a sudden increase in American observations. Dyer (March 15, 1901) reported a case for St. Louis. Schaefer (May, 1901) was reported in the proceedings of the Texas Medical Association (Texas Medical News, May, 1901) as presenting a paper on a new form of intestinal parasite in Texas. The case in question was uncinariasis, probably due to *Uncinaria americana*, but was not published as uncinariasis until October 26, 1901.

Claytor's (June, 1901) case is, so far as I am aware, the first published American case which can be recognized as unquestionably due to *Uncinaria americana*, although at least some (and probably most, if not all) of Ashford's cases were caused by this species. Claytor's case was originally published as an infection with the Old World species, *Agchylostoma duodenale* (an error for which the responsibility rests upon me, not upon Dr. Claytor; the large-sized egg found should have placed me more on my guard).

Allyn and Behrend (July 13, 1901) recorded an imported case in an Italian boy in Philadelphia, due apparently to *Agchylostoma duodenale*, and at the same time mentioned three unpublished cases diagnosed by Dr. L. Napoleon Boston, two in 1900 and one in 1901. All three cases came from Porto Rico, so that they were probably due to *Uncinaria americana*.

^a It is true, as has been stated, that for some years prior to Ashford's publication I had repeatedly insisted upon the probability of the frequent occurrence of this disease in the United States, having discussed the subject in my lectures on medical zoology in the post-graduate medical school of the U. S. Army, and in the medical classes of Johns Hopkins University and of Georgetown University (the latter, the alma mater of Dr. Ashford), as well as in various medical meetings; but so far as I am aware, my views were not printed until July, 1901, so that Ashford's printed statements antedate mine by more than a year. Furthermore, his paper was a practical demonstration, while my views were theoretical deductions.

In a paper (July, 1901) written for the *Texas Medical News* I expressed very positive views to the effect that uncinariasis in man must be more or less widespread in the United States, and I discussed the disease in general. The position taken was based upon general zoologic principles, and, so far as I am aware, was the first printed definite claim regarding the frequency or probable frequency of the malady in the United States.

Schaefer (October 26, 1901) next published a case for Galveston, Tex., probably infected in Mexico, and made the very important statement that Allen J. Smith had found one case in Galveston in 1893, and since then that he had encountered two [afterwards six additional] cases among some 80-odd medical students of the University of Texas.

The importance of this discovery by Allen J. Smith should not be underestimated. To the clinician it did not mean very much, since no record existed that the students exhibited any very severe symptoms. To the zoologist, however, it meant a practical demonstration that uncinariasis was more or less common in the South. Here were 3 [8] students in a city (Galveston); the chances that the infection took place in Galveston did not seem very great; as the students came from different places (according to personal information), the infection must be more or less widespread; and since light cases occurred among medical students, heavier infections must naturally occur among persons who come more regularly in contact with the dirt. Allen J. Smith's observations, the importance of which has not yet been duly recognized by medical journals or by his colleagues, led to some correspondence between himself and me, and he very kindly forwarded specimens from one of his cases. In some respects these parasites resembled *Uncinaria stenocephala* of the dog, and both Allen J. Smith and I were fully agreed that they were not identical with *Alphyllostoma duodenale*. I obtained specimens from Claytor's case and also some material which Ashford had sent from Porto Rico to the U. S. Army Medical Museum. All three lots of worms agreed with each other, and differed from *Uncinaria stenocephala*, which I had obtained from Europe, as well as from *U. trigonocephala*^a from sheep, *U. radiata* from cattle, *U. Lucasi* from the Alaskan seal, and from every other species of *Uncinaria* of which I could obtain either specimens or description. Accordingly, I described (May 10, 1902) these worms as a new species, naming it *Uncinaria americana*.

Having now an endemic species, with specimens in my possession for Washington, D. C. (patient came from Virginia), Porto Rico (Ashford's material), Cuba (specimens sent by Guiteras), and Galveston (Allen J. Smith's material), I did not hesitate to state positively in

^a *U. cernua* (Creplin, 1829). See Stiles, 1902b, p. 189.

a paper published in the Eighteenth Annual Report of the Bureau of Animal Industry, and issued on September 25, 1902, that we must have in the United States an endemic uncinariasis which had been generally overlooked.

Prior to the appearance of the paper in question, Claude Smith, of Atlanta, Ga. (June, 1902), had presented a case of uncinariasis before the American Medical Association (see below, p. 103), the parasite afterwards proving to belong to the species *Uncinaria americana*.

H. F. Harris (July 19, 1902), also published a case of uncinariasis (see below, p. 103) for Georgia. In reply to a letter from me, he stated (August 9) that he had found other cases also, and that he was "absolutely sure this disease is very common in this [Porter Springs] locality."

Upon my transfer from the United States Bureau of Animal Industry to the United States Public Health and Marine-Hospital Service, I decided upon an early study of uncinariasis in man, to determine its frequency and geographic distribution in the Southern States. A preliminary report (Stiles, 1902c, October 24) was published, giving my results for Virginia, North Carolina, and part of South Carolina. This report reads as follows:

[Reports to the Surgeon-General Public Health and Marine-Hospital Service.]

HOOKWORM DISEASE IN THE SOUTH—FREQUENCY OF INFECTION BY THE PARASITE
(*UNCINARIA AMERICANA*) IN RURAL DISTRICTS.

(Preliminary report by Dr. Ch. Wardell Stiles, chief of Division of Zoology, United States Public Health and Marine-Hospital Service, detailed for this investigation.)

KERSHAW, S. C., October 22, 1902.

SIR: Through the director of the Hygienic Laboratory, I have the honor to submit a brief preliminary report in regard to the frequency and geographic distribution of hookworm disease (uncinariasis) in the Southern States.

Meeting the disease in the Virgilina copper-mine district of southern Virginia and northern North Carolina, I have thus far traced it through the coal-mine district of Cumnock, N. C., the brickyards of Camden, S. C., and the granite-sand district of Lancaster and Kershaw counties, S. C.

The present indications are that it is more prevalent in sandy regions than in clay or stone districts. On the farms and plantations of the sand region of the two counties just mentioned, it appears to be the most common disease of man, and from an economic point of view it appears to be of great importance. The extreme cases seem to occur more commonly among children and women than among adult males over 25, but the present facts at my disposal do not indicate that the malady is quite so fatal as the European form of the disease caused by *Uncinaria duodenalis*. All of the cases thus far examined are due to *Uncinaria americana*, demonstrating clearly that this is an endemic infection and totally independent of the cases which have been introduced from Europe, Asia, and northern Africa.

In general, it may be said that the "pale skin," the "heart disease," the "diarrhea," the "bloat," and the suppression of menses which I have thus far examined all represented various stages of heavy infections with *Uncinaria americana*, and it is impossible to escape the conclusion that so far as the farms and plantations

are concerned a radical change in the general therapeutics practiced in the localities in question is urgently indicated.

As for the economic side of the problem, it should be recalled that the disease in question is resulting in loss of wages, loss in productiveness of the farms, loss in the school attendance of the children, extra expenses for drugs and for physicians' services, etc.

The heavy and frequent infections found are amply explained by the almost total absence of privies and closets on the farms visited. Defecation occurs at almost any place within a radius of 50 meters from the house or hut, and as a result the premises become heavily infested with the embryos.

The disease as thus far traced is primarily a "poor man's" malady, and in frequency it far exceeds even the most extreme limit which theoretical deductions seemed to justify before commencing the field work. There is, in fact, not the slightest room for doubt that uncinariasis is one of the most important and most common diseases of this part of the South, especially on farms and plantations in sandy districts, and indications are not entirely lacking that much of the trouble popularly attributed to "dirt-eating," "resin-chewing," and even some of the proverbial laziness of the poorer classes of the white population are in reality various manifestations of uncinariasis.

The infection among the miners, so far as discovered, is less severe and less common than the infection on the farms and plantations of the sandy districts.

Respectfully,

CH. WARDELL STILES, Ph. D.,
Chief of Division of Zoology.

On November 15, Dr. H. F. Harris, of Atlanta, Ga., published an important notice regarding uncinariasis in the South. After referring to his first case (see above, p. 35), he says:

"The discovery of a distinct American species of the hookworm is very important, as it leads to the inference that the aborigines of this country were infested with this parasite, and that the worm is probably present in all parts of the United States where the conditions are suitable for its development.

"My observations during the last six months bear out this assumption in a most striking manner. A few weeks after my first case of the disease was seen, a second one was encountered that originated in middle Georgia, but though I was constantly on the search for it no other case was found among the numerous patients that come to the clinics of the Atlanta College of Physicians. In June of the present year I made a trip to north Georgia, a region that has long been noted as one in which the inhabitants are very pale and anæmic, this condition being commonly reputed to be the result of dirt eating. Here I saw many instances of what was in all probability ankylostomiasis; but as a result of the ignorance of the people and their suspicion of all strangers a proper examination could be obtained in only four cases, in all of which the parasite was demonstrated. Subsequently a case of the disease was seen that originated in middle Alabama. During September and October I have been studying malaria in south Georgia and Florida, a region in which the people show profound anemia even more often than in north Georgia. This condition is commonly ascribed to malaria, but my observations show that in almost all instances the sufferers have no malarial parasites in their blood, but eggs of the ankylostoma are constantly found in the feces. During my entire stay in this region I only saw one case of profound anemia from malaria, and in this instance the patient did not exhibit the extraordinary anemia so commonly found in those infested with the ankylostoma. I feel no hesitation in saying that time will show that by far the greater number of cases of anemia in Georgia, Alabama, and Florida are due not to malaria but to the ankylostoma, and that this is the most common of all the serious diseases in this

region. There can be no reasonable doubt that what is true as regards the States named likewise holds good for the entire South. Since my first case was reported 13 other instances of the disease have been seen—11 originating in this State, and 1 each in Florida and Alabama; and if all of those encountered who were suffering from anæmia could have been examined there can be no doubt that the number would be many fold greater.

"This communication is written in the hope that Southern physicians will take up this most important matter at once, for in no other serious disease does the victim suffer so long, in no other condition is he for such a period a menace to those about him, and in no other malady of such gravity is the treatment so rapidly and surely successful."

ITINERARY OF TRIP THROUGH THE SOUTHERN ATLANTIC STATES.

DISTRICT OF COLUMBIA.

In September, 1902, with the aid of three assistants (Messrs. P. E. Garrison, B. H. Ransom, and E. C. Stevenson) I began a systematic study of animal parasites among the patients of Government Hospital for the Insane, District of Columbia. From September 10 to December 12, 1902, the stools of 500 male patients were examined microscopically and 15 patients, or 3 per cent, were found to be infected with hookworms. The history has not yet been examined for each case, but probably most of the patients became infected in Cuba, Porto Rico, or the Philippines.

VIRGINIA.

Richmond and State farm.—Starting on my field work, my first stop (September 25) was Richmond, Va. Through the courtesy and cooperation of Dr. Charles V. Carrington I was able to examine at the State penitentiary and the State farm nearly 1,200 convicts. The prisoners filed past Dr. Carrington and myself in single file, and we selected those who appeared anemic or debilitated. Those selected were sent to the hospital and kept there until specimens of feces were obtained. In microscopic examination of 6 white male convicts no case of uncinariasis was found. The only zooparasitic case noticed was an exceedingly heavy infection with whipworms (*Trichuris trichiura*) in a man about 70 years old.

In 22 male negroes the examination was likewise negative so far as *Uncinaria* was concerned, but one case of infection of celworms (*Ascaris lumbricoides*) was found. In several of the convicts starch digestion or meat digestion was poor, but in most instances the debilitated condition was due to tuberculosis or other diseases.

At the almshouse in Richmond 1 white female 28 years of age gave negative results; a weak-minded girl of 7 years showed a heavy infection with whip worms (*Trichuris trichiura*). In two negroes (1 male, 28 years; 1 female, 30 years) the examination was negative.

"In 350 female patients examined to March 1, 1903, only one case of hookworm infection has been found.

It proved to be so difficult to obtain specimens of feces from the brickyards that no microscopic examinations were made. No clew was obtained to any disease among the workers which could be interpreted as probable uncinariasis.

Besides Dr. Carrington, I am indebted to Dr. Staton also for cooperation in my work at Richmond.

NORTH CAROLINA.

Virgilina Copper Mine district, southern Virginia and northern North Carolina.—Proceeding to the Virgilina copper mine district I found it very difficult at first to obtain specimens for examination. At one mine 1 white male and 3 negro males were examined; all were negative except 1 negro 22 years old, who showed infection with *Ascaris lumbricoides*. At this mine defecation under ground is prohibited; it occurs in the surrounding woods, at any place within a radius of about 50 meters from the shaft.

At a second mine three specimens of feces were taken at random from the woods; eggs of *Uncinaria americana* were found in one specimen, and ova of *Ascaris lumbricoides* in a second. The patients could not be traced. Specimens were then obtained from 4 white and 18 negro miners, the feces being taken without reference to the physical condition of the men. Of these 22 men, 1 negro 25 years old showed a light infection with *Uncinaria americana*, and inquiry developed the fact that he "had not been well for some time." His chief complaint had been "diarrhea." In two other cases, a white man 41 years old and a negro 34 years old, eggs of the celworm (*Ascaris lumbricoides*) were found. At this mine defecation under ground is prohibited, and a box privy is located within about 50 meters of the shaft. The men prefer, however, to defecate in the surrounding woods.

I am indebted to Drs. F. D. Drewry and P. P. Causey, and to Mr. L. N. White, manager of the Person Consolidated Copper and Gold Mines Company at Durgy, N. C., for their kind cooperation in connection with my work in Virgilina and vicinity.

Cummock Coal Mines, Chatham County.—The miners at this place were so suspicious regarding my work that it was almost impossible to obtain specimens for examination. In fact only two specimens could be obtained from about 40 men. One of these, a white miner, 52 years of age, and in rather anemic condition, showed infection with *Uncinaria americana*. The other, a white engineer, 34 years old, gave negative results.

Sanford, Moore County.—Specimens from 4 whites (2 males, and 2 females), obtained by 2 of the local physicians, were examined with negative results.

SOUTH CAROLINA.

Camden, Camden County. Unexpectedly delayed at Camden, I visited the brickyards with Dr. J. W. Corbett. Of 7 specimens of feces picked up at random from the ground, probably most if not all from negroes, 1 was found infected with *Uncinaria americana*. One white laborer also showed infection with the same parasite.

Haile Goldmine, Lancaster County.—Through the kindness of Captain Thiess, the superintendent of the mines, and Dr. Gregory, the local physician, I was able to examine specimens from 5 white men and 5 negroes connected with the mine. All of these examinations were negative.

Upon leaving Richmond I happened to recall the observation made by Lucas (in Jordan & Clark, 1898, p. 70) in connection with uncinariasis of the seal pups of Alaska, namely, that the infected animals were almost invariably found on the sand rookeries; I also recalled that I had observed severe outbreaks of uncinariasis in sheep and goats on more or less sandy pastures, and further that a severe outbreak of the same disease among dogs had once been reported to me as occurring in a sandy yard. Not recalling at the time any similar observation for uncinariasis in man, I determined to test the subject at the first opportunity, and from Richmond to Haile Goldmine I had diligently inquired of every physician I met, whether he found more anemia on sand, clay, or rock soil. Most physicians replied that they had paid no attention to the subject; one physician stated that he thought anemia was more common in sandy than in clay localities.

Through Captain Thiess I learned that the land near the mines was chiefly a granite sand. With Dr. Gregory, I drove about 4 miles into the sandy district in Lancaster County and found a family of 11 members, one of whom was an alleged "dirt-eater." The instant I saw these 11 persons I recalled Little's (1845) description of the dirt-eaters of Florida. (See Stiles, 1902b, p. 208.) A physical examination made it probable that we had before us 11 cases of uncinariasis, and a specimen of feces from one of the children gave the positive diagnosis of infection with *Uncinaria americana*. There were hundreds of eggs present.

Inquiring for the largest plantation of this sand district, I was directed to a place in Kershaw County, about 6 miles from Kershaw, and through the kindness of Dr. Twitty and the owner of the plantation, I was able to make the desired examinations.

There are about 60 white "hands" on this farm. Going to a field I found about 20 at work. These 20 persons, men, women, and children, corresponded in more or less detail to the description of the so-called dirt-eaters and resin-chewers. A physical examination

showed that they also corresponded to cases of uncinariasis. A family of 10 members was selected and examined carefully. Specimens of feces from 4 of them were examined microscopically and found to contain hundreds of eggs of *Uncinaria americana*. The owner of the plantation informed me that it would be a waste of my time to examine the remaining 40 "hands," as they were in exactly the same condition as the 20 already examined.

Driving to a neighboring farmhouse, I found a family of 5 members, 3 of whom presented such severe and typical symptoms that I had no hesitation in diagnosing them as due to uncinariasis.

Kershaw County.—While driving back to Kershaw, I passed a country schoolhouse. The children, about twenty-five or thirty in number, were at play during recess, and a mere glance at them was sufficient to show that 30 to 40 per cent presented the same general appearance as the children on the neighboring plantation.

At Kershaw several extreme cases were met on the street. The persons in question had come in from the country. One farmer, living about 9 miles away from Kershaw, had with him two of his children. He stated that his entire family, 10 in number, had suffered or were suffering in the same way as these two boys. Physical examination made uncinariasis probable, and the microscopic examination of the feces showed heavy infections with *Uncinaria americana*.

Inquiry among the local physicians and the more intelligent laity elicited the information that the cases that I had seen represented conditions which were usually attributed to "dirt-eating," "resin-chewing," "heart disease," "bloat," "amenorrhea," "anemia due to malaria" (mosquitoes were noticeable chiefly by their absence), "general debility," "poor nourishment," etc. I was further assured that these conditions were general throughout this region, and were not, or only slightly, amenable to treatment.

Taking these cases together, some forty or fifty in all, which I examined carefully within three days, we have one common symptom, namely, *anemia*; nearly all other symptoms noticed could be reduced to sequelae of *anemia*; further, in every case examined microscopically, exceedingly heavy infections with *Uncinaria americana* were found. Under these conditions, and because the general clinical history corresponded so well with uncinariasis, I have not the slightest hesitation in grouping the cases observed as due to *Uncinaria americana*.

Charleston, Charleston County.—Through the kindness of Drs. John Dawson and Robert Wilson, jr., I was able to meet the students of the Charleston Medical College. Explaining the object of my trip, I asked for volunteers to submit to microscopic examination. Sixteen of the students and 1 member of the faculty immediately volunteered. Of these 17 men (all white, of course), 4 were found infected with *Uncinaria americana* and 1 showed a heavy infection with

Hymenolepis nana. The cases of uncinariasis came from the sand districts—namely, Barnwell County; Florence, Saint John County; a sea-coast island near Charleston, and Edisto Island, Charleston County.

Through the courtesy of Dr. Huger and the ladies in charge of the Charleston Orphan Asylum, I was able to examine 230 white children, both boys and girls. I picked out 20 for closer examination, because of the anemic condition, or stunted growth, etc. Of the fecal specimens obtained, 15 showed infection with *Uncinaria americana*. All of the children came from sandy districts of the State—namely, Summerville, Dorchester County; Berkeley County; Adams Run, Colleton County; Plum Island, Charleston County, and McClellanville, Charleston County. One additional case failed to show eggs in the feces, but the clinical history during early childhood seemed typical for uncinariasis (see p. 58, case of L. B.). Of the 4 remaining cases (2 from Charleston (city) and 2 from Edgeville), 1 Charleston boy 11½ years old and 1 Edgeville boy 11 years old showed infection with whip worms (*Trichuris trichiura*).

Besides the Charleston physicians mentioned above, I am indebted to Dr. Grange Simons, president of the State board of health; Dr. J. Mercier Green, city health officer, and several other gentlemen, for their kind cooperation in my work. Dr. De Saussure stated to me that he had found the eggs of *Uncinaria* in the stools of several patients.

GEORGIA.

Atlanta, Fulton County.—Learning incidentally that Drs. Claude A. Smith and H. F. Harris were continuing their studies on uncinariasis in Atlanta, I left the city without seeing any cases personally. No reason was apparent which made it necessary to confirm their work for this locality, and, furthermore, the territory belonged to them as local men who were carrying on their investigations at their own expense.

In connection with northern Georgia it may, however, be stated that according to Dr. Lamartine G. Hardman, a member of the Georgia legislature, a condition exists in Jackson County, Ga., which corresponds to what I found in Kershaw and Lancaster counties, S. C.

Macon, Bibb County.—Through the kindness of the local physicians I was able to examine two white orphan asylums in Macon.

In one of these, Dr. Clark (consulting physician) and I selected from among the 85 children 17 boys and girls for closer examination. The selection was made in the same manner as at Charleston, namely, because of the pale, weak, or otherwise poor condition. Microscopic examination showed 12 cases of infection with *Uncinaria americana*, 2 cases of infection with *Hymenolepis nana*, and 3 negative cases. The uncinariasis cases came from sandy districts, namely: Americus, Sumter County, 1; Buena Vista, Marion County, 2; Thomasville, Thomas

County, 1; Savannah, Chatham County, 1; and Waycross, Ware County, Ga., 1; and Wacissa, Jefferson County, 1; De Land, Volusia County, 4; and Liveoak, Suwanee County, Fla., 1. Both *Hymenolepis* cases came from Georgia.

At another orphan asylum, through the kindness of Dr. Little, the consulting physician, I examined 112 white children, all from Georgia. I selected 21 for closer study, and the microscopic examination of the feces revealed 17 cases of infection with *Uncinaria americana*, 1 light infection with *Hymenolepis nana*, and 2 negative cases, 1 of which was doubtless malarial. The 17 cases came from the following places: Baxley, Appling County, 1; Cordele, Dooly County, 1; Darien, McIntosh County, 1; Effingham County, 1; Johnson County, 1; Jones County, 4; Kinderloun Station, Lowndes County, 1; Lyon, Tattnall County, 1; Monroe County, 1; Richwood, Dooly County, 2; Sandersville, Washington County, 1; Waycross, Ware County, 2.

Four cotton mills were next inspected, some of the houses of the factory hands were visited, and about 25 or 30 cases of uncinariasis were found. Inquiry developed the important facts that the infected persons had come to the mills from the rural sand districts, and that in general their condition improved with their residence in the city. An examination of the premises, both of the mills and of the houses, did not indicate that the disease would spread.

At a negro school in Macon I failed to find a single case of uncinariasis which could be diagnosed symptomatically with even a semblance of confidence. In one case only did I even suspect the disease.

"Circus day" brought thousands of people into view on the streets, many coming in from the surrounding country. Several cases of probable uncinariasis were observed among the whites, but none among the negroes.

Besides the Macon physicians mentioned above in connection with the orphan asylums, I am under obligations to Dr. A. M. Burt, and especially to Dr. H. McHatton for their cooperation in my work.

Milledgeville, Baldwin County.—Through the kindness of Dr. T. O. Powell, superintendent, and Dr. M. L. Perry, pathologist, of the State sanitarium, I was able to see a large number of the patients. Extreme cases of anemia were conspicuous by their absence. Two patients were selected as possible cases of uncinariasis, the microscopic examination being left in the hands of Dr. Perry, who has kindly written me that it was negative.

Fort Valley, Houston County.—With the cooperation of Dr. M. S. Brown, a local physician, I found about 10 cases of uncinariasis near town within an hour's time. The clinical histories were so typical that it was considered scarcely necessary to make a microscopic examination; nevertheless this was done in one case with the result of finding a severe infection with *Uncinaria americana*. After seeing the class of cases I desired to find, Dr. Brown assured me that they

were common in that region, and that he could easily find 50 or more cases within a day's time.

Albany, Dougherty County.—Leaving the sand district I next visited Albany, which is surrounded by clay. Corresponding to the change in the soil there was a change in the medical facies. Uncinariasis disappeared, except for cases which came in from the neighboring sand districts, while malaria increased. Dr. Hilsman, one of the local physicians, kindly drove around with me to find cases, but we were obliged to go about 15 kilometers (9 miles), namely, into Lee County, before we located a family with uncinariasis. During this drive we left the clay soil and passed into a sand district, with pine woods. The family in question presented four typical extreme cases; although microscopic examination for sake of diagnosis seemed unnecessary it was nevertheless made and showed heavy infection with *Uncinaria americana*.

While with Dr. Hilsman in Albany I made a most fortunate mistake in diagnosis. The patient was a boy about 13 or 14 years old. He had a clear case of malaria (typical history, enlarged spleen, etc.), but in addition to that I was confident that he had a medium or light infection with uncinariasis. Microscopic examination proved me in error. This boy lived in a clay district and had never lived in sand; furthermore, he did not show the eye symptom, which I shall discuss later (see p. 65). This is the last time I attempted a definite diagnosis upon symptoms of any medium or light case unless severe cases occurred in the same family.

As soon as Dr. Hilsman understood the kind of cases I desired to see he stated, with the utmost positiveness, that they did not arise in and around Albany until the sandy soil was reached. Occasionally cases came to Albany from the neighboring sand counties, but the local anemia Dr. Hilsman considered to be almost entirely of malarial origin—an opinion in which I can only concur after what I saw in that city.

I happened to be in Albany on Saturday, when the country folks for miles around come to town. Standing on the street corner for several hours, I must have seen about 200 whites and fully 3,000 negroes who drove or walked into town. Of the whites, I noticed about 5 cases of probable uncinariasis. Two of the cases, whom I was able to interrogate, gave a typical history of uncinariasis extending back for several years, but no history of malaria. They came from neighboring sand counties. Among the 3,000 negro men, women, and children, whom I saw, there was only one person in whom I even suspected from his general appearance that uncinariasis might be present.

Willacoochee, Coffee County.—In southern Georgia, Coffee County bears the reputation of being more or less a center for dirt-eaters. It is a sandy, pine-wood district, with numerous swamps, which indicate a more impervious subsoil. As a result, both malaria and uncinariasis

were found, and it was exceedingly interesting to note the ease with which an error in diagnosis in medium and light cases could be made if the microscope were not used. Extreme cases, however, could be easily distinguished without the microscope. Several cases of typical extreme uncinariasis were seen on the street, but not examined carefully. Then, through the kindness of Dr. Wilcox, I was able to make a careful examination, both physical and microscopic, of a group of 8 cases at the sawmills a short distance from town. After Dr. Wilcox examined these cases with me, he declared that he knew of at least 200 similar patients within the territory of his practice. He considered this condition one of the most common diseases of that region, but thought malaria was fully as common if not more so.

Waycross, Ware County.—Passing now to Waycross, I entered a district where uncinariasis is exceedingly common. Drs. R. P. Izlar and J. L. Walker assured me that the cases I was tracing, two of which I saw with Dr. Walker, were much more common than was malaria, the proportion being about 20 to 1. In this district these patients are called "Branch-water people." Both Dr. Izlar and Dr. Walker stated that they could easily show me scores of cases within a radius of a few miles.

FLORIDA.

Jacksonville, Duval County.—In Jacksonville two cases of typical uncinariasis were seen on the street. One of these patients was traced to the county in which the boy had formerly lived.

Both the State and the city health offices assured me that the condition I was hunting was perfectly familiar to them—that it was prevalent throughout the State, especially in the "flat-woods district," and that Florida physicians interpreted it as an anemia due to malaria and improper diet.

Waldo, Alachua County.—Through the kindness of the local physician, Dr. J. W. Boring, I was able to examine two groups of typical cases of uncinariasis within a short distance from town. Dr. Boring assured me that this condition was exceeding common in Florida and was generally interpreted as an anemia due to malaria and improper diet.

Ocala, Marion County.—In Ocala I saw several typical cases of uncinariasis on the street, and, through the kindness of Dr. A. L. Izlar, I was able to examine 5 positive cases and 1 probable case more closely. Dr. Izlar confirmed the statements of the health offices in Jacksonville, Fla., relative to the frequency and interpretation of the disease.

From Ocala I returned (November 16) directly to Washington, D. C., and noticed several cases which presented the appearance I had found typical of uncinariasis, as the train stopped at various stations in Florida.

SYMPTOMATOLOGY OF UNCINARIASIS.^a

In connection with the symptoms, let us recall that uncinariasis is caused by hookworms about half an inch long which live in the small intestine for several meters below the stomach.

These worms fasten to the mucosa and suck blood. They lay numerous eggs, which can be found by a microscopic examination of the stools. The number of eggs in the feces and, in a general way also, the severity of the symptoms will vary with the number of parasites present and with the duration of the infection.

The injury to the patients results from the following factors: (1) Sucking of blood by the parasites, which is a constant drain on the system; (2) loss of blood into the intestine through the minute wounds made by the parasite, a factor which also tends to deplete the system; (3) the wounds form points of attack for bacteria, hence increase the chances of bacterial infection as well as of toxic infection from partly digested and decomposed food; (4) the wall of the duodenum and jejunum becomes thickened and degenerated, and its function is thus decidedly interfered with; (5) the parasites in all probability produce a poisonous substance which acts upon the patient.

Theoretically there is only one sign which is present in every case, namely, the presence of one or more parasites in the intestine. If

^aThis discussion of symptoms will be influenced to no slight degree by the fact that during my trip my associates have been almost entirely practicing physicians, particularly in rural districts, rather than laboratory specialists; and, since it is more particularly the country practitioner whom I desire to reach by this paper, I shall not hesitate to use vernacular names even if these do not invariably have a classical origin.

My trip was undertaken in order to prove the frequency and geographic distribution of the parasite, not to study the symptoms it causes. It was therefore a zoological, not a clinical, trip, and on this account a zoologist, not a clinician, undertook the investigation. Not posing in any sense of the term as a clinician, I feel that any observations which I have made upon symptoms, *sensu stricto*, should be looked upon as over and above the amount of work which should be justly expected of me. Certain symptoms I could not help noticing. The circumstances of my trip, the rapid travel, short stops, and the fact that the work was done among strangers, and usually in the field instead of in a hospital, absolutely excluded certain observations, even had I considered that I was the proper person to make them.

If, therefore, the reader misses in this discussion observations on any particular symptom in which he is especially interested, I beg that he will recall that it is self-understood that the finer points in symptomatology must be studied by expert clinicians.

I regret that it is not feasible for me at the present time to review the entire medical literature on uncinariasis. Such an undertaking would involve an unjustifiable delay in sending much-needed information to physicians in the infected district.

In connection with my own observations, however, I shall make frequent references to the noted paper entitled "Observations on 400 cases of ancylostomiasis," published in 1894 by F. M. Sandwith, M. D., physician to the Kasr-el-aini Hospital, Cairo, Egypt; thus supplementing my description with the views expressed by a trained clinician.

these worms are in an egg-laying stage ova will be found in the feces. But from a practical standpoint, severe cases present what seems to be a characteristic type, and even medium cases often present a more or less typical clinical history.

The statement is not infrequently made that there is one way and only one way to diagnose a case of uncinariasis, namely, by examination of the stools to find the parasites or their eggs.

Academically this statement is more or less correct, yet practically



FIG. 42.—A severe case of hookworm disease observed in Florida. Note the bloated face, the drooping shoulders, the prominent abdomen, and the thin arms and legs. This girl is about fifteen years old. Original, from a kodak photograph.

it should be somewhat modified. Sandwith (1894, p. 13), to quote from a clinician, states that "facies of the patient is characteristic, though it is difficult to describe his discontented, harassed expression, which sometimes changes to a ready smile after a month's stay in a hospital." The data at my disposal would lead me to divide the cases of hookworm disease I have observed into three general but not very sharply defined classes, namely:

(1) *Light cases*, including those in which practically no distinct symptoms of the disease are noticed, but in which a few hookworm

eggs are discovered in the stools. We may also place here a number of cases in which, in addition to the presence of eggs, there is a slight diarrhea or some other slight symptom, including more or less rapid exhaustion after physical exertion, hence an indisposition to work, which is usually interpreted as laziness. Cases of this class are found in the infected areas and elsewhere, since infected people may move away from the sand districts.

(2) *Medium cases*, including those in which the disease has progressed to such an extent that a more or less anemic condition is noticed, but other symptoms are not especially marked. If these patients were found outside the infected area, the diagnostician (especially if he is not familiar with the disease) would probably not see anything particularly characteristic in them; many of these cases, however, show a more or less typical history, and if a history of residence upon sandy soil in tropical or subtropical regions can be obtained, uncinariasis should certainly be strongly suspected. If these cases occur in a family which also presents severe cases of uncinariasis, the diagnosis of hookworm disease in the medium cases is usually quite safe, even if a microscopic examination is not undertaken.

(3) *Severe cases*, in which we find that striking set of symptoms which even the laity in our Southern States attributes to "dirt-eating." These patients present a facies which is well recognized by Southern physicians. If the patient is found in a Southern sand area, the diagnosis is practically certain. If found outside of the infected area, with a history of previous residence in a Southern sand district, its recognition symptomatically ought not to be attended with difficulty. In case of doubt, if a microscope is at hand, the test may be made in less than five minutes; if no microscope is at hand, the blotting paper test (see p. 81) will usually suffice.

Turning now to an analysis of symptoms, I will give my observations on the severe cases. It is needless to state that the symptoms discussed may vary in intensity, and that not every symptom mentioned is found in every severe case. We find on the contrary an imperceptible gradation between the severest and the lightest cases.

GENERAL PREDISPOSING FACTORS.

INFECTION OCCURS CHIEFLY ON SANDY SOIL.

In connection with the clinical history, the residence on sandy soil is undoubtedly one of the most important points to be obtained. If an anemic patient gives no history of temporary or permanent residence on a sandy soil, uncinariasis is not absolutely excluded, but according to my experience the chances are against it. If on the other hand a history of sojourn or residence in a sandy rural district is obtained, the probabilities of uncinariasis are decidedly increased.

Nearly every case of the disease found during the entire trip was either living at the time in a sandy district or had lived in such a place a few years previously. As soon as I entered the sandy areas, uncinariasis was found. As soon as I left the sand, as at Albany, local foci of infection of uncinariasis disappeared.

Inquiry among physicians at first failed to elicit any definite statement regarding the soil on which anemia was most frequent, but upon going farther south several physicians were met whose experience fully confirmed my observations on this point. One physician in particular, Dr. A. M. Burt, of Macon, was of the emphatic opinion that in bringing the condition which I have interpreted as uncinariasis into connection with the sandy soil, I had found the keynote to the distribution of the entire disease. Dr. McHatton, of Macon, called my attention to the fact that in antebellum days the slave owners in the Lower Mississippi Valley frequently provided special quarters, which were removed from the sand districts, and to which they sent the dirt-eating and other sick negroes and also negresses about to be confined, the view being held that a clay soil was more salubrious than a sandy soil. This view, in fact, I found to be rather prevalent among the farm hands. Time after time they remarked, "We were never sick so long as we lived in a clay district," "This disease developed after we moved upon sand," etc.

This view that uncinariasis follows the sand is supported by evidence obtained in Alaska by Mr. F. A. Lucas. After the discovery was made that uncinariasis, caused by *Uncinaria Lucasi*, was prevalent among the seal pups, Lucas (see above, p. 39) showed that it was practically only the seals on the sandy rookeries which were infested with the parasites.

As stated above (p. 39), I have also observed two outbreaks of uncinariasis among sheep and goats, caused by *Uncinaria trigonocephala* (Rudolphi, 1809) Ralliet, 1900, on more or less sandy soil, and have further confirmatory facts in connection with one outbreak of the disease among dogs. Since returning from my trip I have found at least one reference in literature on uncinariasis and ground itch to the effect that the soil in districts where certain cases have occurred was more or less sandy (see p. 62), but I have not yet found that any author lays stress upon this point.

In view of all the data at hand, I have no hesitation in expressing the opinion that uncinariasis, caused by *Uncinaria americana*, is pre-eminently a disease of sandy localities and that cases found in clay or rocky areas can usually be traced to a former visit or residence in a sandy place.

Just why this disease should follow the sand rather than the clay is not absolutely clear. Three explanations have occurred to me as working hypotheses which, though not absolutely satisfactory as final, will, I believe, explain part of the mystery.

(1) We know that uncinariasis is spread through the feces; we know further that when the embryos hatch from the eggs they leave the feces and enter the surrounding water or moist earth, while there is no satisfactory evidence to show that they are blown around in the air in a dry state. (See Stiles, 1902b, p. 199.) Now, assume that a person walks over infected ground; if that ground is clay, he does not disturb the embryos which have crawled beneath the surface, except in wet places; if, on the other hand, the ground is sand, he not only stirs it up while walking, thus bringing the young worms nearer the surface again and thereby increasing their chances of producing an infection, but he is also likely to carry away particles of sand, together with embryos, with him on his shoes or feet, thus increasing his chances of becoming infected. It is further clear that children playing in sand will stir up more embryos than when playing on a clay soil, and will thus increase their chances of infection.

(2) An additional explanation is that water will not pass through clay as it will through sand; hence on clay soil the embryos stand a greater chance of perishing or of being washed by rain into the streams. On sand, however, the embryos might perhaps work their way through the soil with the water, and thus infect surface wells. In advancing this hypothesis, I am not unmindful of the view, supported by excellent observers, that, since the embryos sink in water, drinking water is not necessarily a common source of infection. Granted that they do sink in water, a water bucket in a well also sinks, and the water from surface wells frequently contains sand particles that are heavier and larger than *Uncinaria* larvæ; hence we can not altogether ignore the drinking water as a possible source of infection. If, on the other hand, drinking water were the only source of infection, it is probable that in families where uncinariasis exists the intensity of the disease would show a greater tendency to uniformity.

Giles has examined 56 specimens of water from wells and ponds of villages affected with hookworm disease and 16 of these he found by chemical and microscopical examination to be "bad" or "very bad." Yet on only one occasion did he find a rhabdite of doubtful origin in water. (Sandwith, 1894, p. 9.)

(3) Oxygen is necessary to the development of the embryos and larvæ, and it does not seem unreasonable to assume that sand would

"In an article which has just appeared, Looss (1903, p. 331) says:

"Further, during the six years of my residence in Cairo [Egypt], I have not heard, up to the present time, of a single case [of hookworm disease] in an European (my own case, of course, excepted). This fact speaks all the less [so much the less] in favor of the assumption of a more common dissemination [i. e., infection] of the disease through the drinking water, vegetables, etc., since [as] the mature hookworm larva, as experiments have shown, pass through the ordinary sand filter with surprising rapidity, and this even when the water is allowed, not to run off, but to stand." [Italics not in the original German.]

on that account present more favorable conditions for the growth to the encysted stage, and probably also a longer preservation of that stage.

In this connection it may be noted that Looss has used charcoal as a medium in which to cultivate the larvæ of *Agchylostoma duodenale*.

INFECTION OCCURS CHIEFLY IN THE RURAL DISTRICTS.

Since the infecting agent of uncinariasis is spread through the feces, we may expect to find infection taking place (other things being equal) in localities where the fecal matter is not properly disposed of. Furthermore, we would not expect that paved streets or grass lawns would favor the development of the disease. We need not therefore expect local foci of infection to occur in cities and towns which have proper sewerage systems and in which the streets and walks are paved and the yards sodded; but we may expect to find local foci of infection in localities where box privies are used but not properly cared for, or where promiscuous defecation occurs in the woods, fields, mines, etc. This condition is in fact exactly what is found. While uncinariasis is not entirely absent from those premises on which the feces are properly disposed of, in cities like Washington, Richmond, Charleston, Macon, Jacksonville, and Ocala, such cases as are found can not be shown to have developed there; but probably in most every case they can be either probably or positively shown to have been contracted elsewhere. In a number of cases I have established this point with a probability, which for all practical purposes may be looked upon as a certainty. We may therefore exclude the greater portion of the inhabitants of sanitary districts of cities from consideration in connection with uncinariasis and may with confidence lay down the general rule that any anemia developing in them as result of local infection (namely infection at home) is much more likely to be due to malaria or other causes than to uncinariasis.

As we approach the outskirts of cities and towns and enter the rural districts, localities in which box privies are used but not always properly cared for, we meet with conditions which are more favorable to infection with the hookworm disease. Accordingly, in cases of anemia, especially in women and children, developing in such localities, uncinariasis must be taken into consideration as one of the possible causes.

Sandwith (1894) states that his patients came from all parts of Egypt except some of the seaport towns.

As we go into the country and visit the farms we not infrequently find a condition, in respect to the disposal of fecal discharge, which almost beggars description. Taking the rural districts visited during my recent trip as example, it is not an exaggeration to say that with the exception of the planters' premises, not over half of the country houses or huts of the sand regions have any privy at all; if there is

one present, it is rarely properly cared for; furthermore it is the exception rather than the rule that it is used. As a result uncinariasis is widespread, not because the country air is particularly favorable to its development, but simply because so little attention is paid to the proper disposal of the fecal discharges.

SYMPTOMS ARE MORE SEVERE IN SUMMER THAN IN WINTER.

It is almost universally conceded that the patients are in better condition in winter than in summer. According to testimony, the symptoms begin to increase in the spring and to decrease in the early winter. This periodicity will be noticed, of course, only in localities which are above the frost line, and it is easily explained when we take into consideration the biology of the parasites. Cold retards and heat hastens the development of the eggs and the embryos; a freezing temperature of 24 to 48 hours' duration, it is said, kills both eggs and embryos. Accordingly, after frost sets in in the fall, the patients will add less to the infection which is present in their bowels than they will during the summer. Some of the worms already in the intestine will be passed, thus decreasing the number of parasites present; the patient will accordingly lose less blood and will on this account feel somewhat better. As warm weather begins in the spring the free eggs and embryos will develop more rapidly and the infection will be increased. There will be more parasites in the intestine, hence symptoms will be augmented.

Some few patients, however, insist that they are better in summer than in winter.

It is probable that the seasonal periodicity of the symptoms noticed in our Southern States will be modified in the Tropics, so that the symptoms will increase in severity in the rainy season and decrease in the dry period of the year. Such a periodicity would correspond to the biologic fact that the eggs and embryos perish very quickly upon becoming dry.

In patients who are not subject to continued infection, as for instance those who have left the area of infection, the seasonal periodicity may be expected to disappear.

WHITES APPEAR TO BE MORE SEVERELY AFFECTED THAN NEGROES.

Osler and other observers have already noticed that chlorosis is more frequent in blondes than in brunettes.

Uncinariasis occurs in both blondes and brunettes, and in both the white and the negro, but so far as my observations go the disease is more severe, *or at least more noticeable*, in blondes than in brunettes, and much more severe, as a rule, in the white than in the negro. This observation was supported by all the evidence I could gather from local physicians. In fact, several practitioners declared that they had never seen a case in the negro to recognize it. There is, however, abundant evidence that such cases do occur.

I am at a loss for a satisfactory explanation of the comparative freedom from uncinariasis noticed in the negro. They live under the same conditions as the poorer classes of the white population, except that, as a rule, the negro farm labor is more common in the rich than in the sand districts; however, negroes also live in infected districts. It is true, as frequently claimed, that some of the negro habitations are more clean than some of the homes of the poorer whites. Still not all negro huts are cleaner than all white huts. The personal habits of the negro children are certainly no more hygienic than those of the white boys and girls.

One factor which may possibly play a rôle in this comparative freedom from the disease on the part of the negro is the fact that negro women very frequently give their children "worm tea," made from certain plants, in order to expel the "eelworm" (*Ascaris lumbricoides*), or they give calomel "to regulate the liver," and this may perhaps also result in expelling the hookworms before the latter have had an opportunity to do much harm. Still this explanation is not altogether satisfactory, especially in view of the testimony of both the local physicians and the negroes themselves to the effect that eelworms are much less common now than formerly, hence "worm tea" is not taken so frequently as in former years.

Chabert (1821a), Jordan (1832), Murray (1843), Le Conte (1845), Duncan (1850), and other authors report "dirt-eating" among the negroes. In fact, nearly all early authors who describe "dirt-eating" lay special stress on the frequency of the habit among the slaves.

In conversation with a negro druggist, I was informed that while dirt-eating was formerly said to be more or less prevalent among the negroes, it was an acknowledged fact among them that the custom had greatly decreased in recent years. In connection with this statement we may note the interesting claim by Cotting (1836a) that there was a reduction in dropsy and dirt-eating corresponding to the more general use of calomel.

Sandwith remarks upon the apparent comparative freedom of the negro from uncinariasis and anemia. Zinn and Jacoby (1896) also refer to the frequent presence of *Agchylostoma duodenale* in negroes of Africa, in whom the anemia was not prominent.

Can it be that the poison produced by the hookworms has less effect upon negroes than on whites and that on this account the disease is less severe in the dark races?

OCCUPATION OF PATIENT.

It is generally acknowledged by writers on uncinariasis that the disease is especially prevalent among people who in their daily work come in contact with earth. In fact, the malady is sometimes called "brickmakers' anemia" or "miners' anemia." Sandwith mentions "peasants" as apparently forming the majority of his patients.

In my own work I was surprised to find that hookworm disease was comparatively light and comparatively rare among the miners I examined. Of brickmakers my statistics are too small to permit any generalization. Two examinations out of eight showed light infections. Most of my cases were from the farming classes.

Sandwith emphasizes the fact that his patients came from the poorest class of the community, and that of 200 men 190 were accustomed to work with their hands in more or less damp earth. Of these 190 men, 152 were agricultural laborers; 18 were masons or bricklayers' laborers; 7 were "scavengers of street refuse and of cesspools, accustomed to emptying with their hands the dry contents of the latter;" 7 were peddlers of unwashed vegetables; 3 limestone carters and scavengers; 1 gardener; 1 fisherman in the mud; 1 "shadouf" worker at the Nile bank; 1 coffee-stall keeper; 3 readers of the Koran; 1 blacksmith; 1 shoeblack; 4 beggars. Sandwith also mentions 20 cases among policemen, who dated their illness from periods of life when working as agricultural laborers.

SEVERE CASES ARE MORE COMMON IN WOMEN AND CHILDREN THAN IN MEN OVER TWENTY-FIVE YEARS OF AGE.

The assertion is frequently made that uncinariasis is more common in men than in women and children. This statement may be perfectly correct in mines and brickyards, but it does not hold good for the farming localities I visited, where the greater prevalence of severe cases in children than in adults, and in women and children than in men over 25 years of age, is very striking. The conditions found, in respect to this point, seem to be due to four factors in particular, namely: (1) The average family in the country districts numbers from, say, 6 to 12. As a rule, 2 or 3 of these can be called adults, and 3 to 9 can usually be classed as children (including minor boys and girls). Since there is a greater number of children than adults subject to infection, we should naturally expect to find a greater number of cases among the children, and our expectations are fully realized. (2) The fact that children and women present a greater number of cases than do the adult males over 25 years of age I am inclined also to explain on the ground that the former are at home more than are the men; the area immediately surrounding the house, for, say, a radius of 50 meters, is a more common place for defecation than are the more distant fields, hence it is more severely infested with the infecting agent. Now, while it is true that, among certain classes, both women and children work in the fields, it is also true that they do this much less than the men. They are at home more, therefore they are on the more intensely infected area for a greater length of time; hence, in respect to actual time they are more subject to infection than are the men, and, other things being equal, they will present a greater num-

ber and a greater proportion of extreme cases. (3) The children in playing in the sand around the house, and owing to their more careless personal habits, are of course especially liable to infection. (4) The men being stronger, are, as a rule, better able to withstand the effects of infection. An interesting and important fact is that men of about 20 to 24 seem in many cases to more or less outgrow the effects of the malady. They give a history of medium or severe infection from, say, 10 to 18 years of age, then at 18 or 20 they begin to improve, and finally appear much better, although their features and physique still show the effects of former disease. This time of improvement corresponds to the years following their first more active participation in work which takes them more away from the house, hence to years when they are subjected less constantly to infection.

Sandwith states that nearly all of his 402 patients were in the prime of life, between 20 and 40 years of age. His youngest case was a boy of 6 years; 48 patients were between 10 and 20 years of age; 170 patients were between 20 and 30 years of age; 140 were between 30 and 40 years of age; 21 were between 40 and 50; 15 were between 50 and 60; and 7 were above 60.

Giles reports a case of a girl 4 years of age. My youngest patient was 3 years old.

Of Sandwith's 402 cases only 3 were females. This statement is in striking contrast to my observations. Sandwith and I made our studies, however, under totally different conditions, for his patients came to his hospital, while I went to the homes of the infected persons. Possibly this will explain, in part, our different results, for he states that "women have not yet learned to apply for hospital relief in the same proportion as the men."

SEVERAL CASES ARE LIKELY TO OCCUR IN THE SAME FAMILY.

Uncinariasis commonly occurs in groups of cases. If one child in a family is accused of being a "dirt-eater," and is shown by physical and microscopic examination to represent an extreme case of uncinariasis, an examination of the remaining members of the family will usually show that most or all of them are suffering from anemia in different degrees, and the microscope will disclose infections with *Uncinaria*. This condition of affairs is so general that it may be looked upon as the rule among farming classes, while the occurrence of isolated cases in a family, except possibly among miners, may be looked upon as the exception. Numerous observations could be cited in support of this view; for instance, in the first family examined in the sand district near Haile Goldmine only one member had the reputation of being a "dirt-eater," but all 11 were in different stages of anemia. In a family of 10 members on a neighboring plantation only 1 was noted as a resin-chewer, but all 10 were anemic. In orphan

asylums it was noticed that if two or more children of one family were present and one child was affected, the other children were also affected. In fact, in every instance where I was able to examine the family to which an alleged "dirt-eater" or "resin chewer" belonged, all or nearly all the members of the family showed an anemia with the general history of uncinariasis, and in every case examined microscopically the eggs were found.

Two families may, however, live very close together, and one family may show several severe cases while the other may not show a single case severe enough to be suspected symptomatically. Thus, on one plantation all the hands examined showed uncinariasis, while the planter's family, of much more cleanly personal habits, did not exhibit any signs of infection. It is, however, more common to find that where one family is affected other families of the same neighborhood will show infection, provided of course that the infected family in question has not moved into a city or a clay district.

The occurrence of cases of uncinariasis of different degrees of intensity in family or neighborhood groups is easily explained by the fact that in a given family or neighborhood all persons are subject to the same general conditions of infection, but owing to differences in age, daily occupation, personal habits, etc., some will be more subject to infection than others.

OBJECTIVE AND SUBJECTIVE SYMPTOMS; ANALYSIS OF SYMPTOMS.

It is difficult to draw a distinct line between the subjective and the objective symptoms. If a patient is left to tell his own story, practically all that the observer will learn is that the patient "feels weak, has a headache, gets dizzy, has fluttering of the heart, finds it hard to breathe, feels worse in summer than in winter, and has 'misery' in the 'stomach.'" In medium cases a few judicious questions, directed more to the parents than to the patient, will as a rule bring to light a history upon which, taken in connection with what one can himself observe, a probable diagnosis may be made. As a rule, little weight can be placed upon the statements made by a patient suffering from an severe infection of uncinariasis. He will answer "yes" or "no" in a most contradictory manner, so that by putting questions in different ways it is practically possible to make him admit or deny, as desired, any particular symptom. It is chiefly from the patient's family that one must judge of what the person has complained.

ONSET AND INCUBATION.

As it takes the parasites four to six weeks to reach maturity after entering the system, the earlier symptoms will be more particularly gastro-intestinal (see, however, p. 60), and even if these are present in a marked degree we can not look for a diagnosis by microscopic

examination of the feces until the worms begin to lay eggs. It is, however, not excluded that some of the young worms might be passed in the stools and be identified, though such a chance is probably more theoretical than practical. In an experimental case of infection through the skin, Looss showed that eggs did not appear in the feces until 71 days after infection. According to Sandwith (1894, p. 12), Surgeon-Major Giles suspected that many of his patients in Assam had suffered from fever at the onset of their malady, and he was confirmed in this impression by observing pyrexia in the monkeys fed on hook-worm embryos.

Looss (1897, pp. 914-915) noticed nausea as the first symptom in dogs to which he fed the larvæ of *Agchylostoma duodenale*.

Bentley (1902 a) practically advances the view that "ground itch" is the primary symptom, and since Looss's view of infection through the skin is correct, at least for some cases, some cutaneous symptom must in such instances be the first symptom of uncinariasis. (See p. 60.)

STAGES OF UNCINARIASIS.

Since my observations of each patient were confined to one or two days, they would not justify me in dividing the disease into stages. Lutz (translated by Macdonald) recognized the following stages:

I. STAGE OF PURELY LOCAL SYMPTOMS.

(a) *Acute form*; (b) *chronic form*.—The symptoms are similar in both forms. The disease is yet limited to pains and disordered digestion; no pallor, no rise of pulse.

II. STAGE OF SIMPLE ANEMIA OR OLIGOCYTHEMIA (CHLOROTIC STAGE).

(a) *Acute form*.—1. Slight degree: Conjunctival vessels still visible; nails and lips pale red; pulse increased in frequency; no blowing murmurs over cardiac area.

2. Higher degree: Conjunctivæ devoid of vessels; nails whitish; lips pale; pulse frequently very much increased; no blowing murmurs.

(b) *Chronic form*.—Anemia has not reached the highest degree. In many cases distinct cardiac hypertrophy and dilatation; in other cases disordered valve closure; seldom both combined. Moderate increase of frequency of pulse.

III. DROPSICAL STAGE.

(a) *Acute form*.—A high degree of anemia; pulse small, much increased in frequency; no blowing murmurs; edema of a hydremic character.

(b) *Chronic form*.—Symptoms of cardiac defects, with disturbed compensation, or of fatty degeneration; distinct symptoms of cyanosis; dropsy of engorgement; anemia of varying intensity; disordered nutrition.

DURATION OF UNCINARIASIS.

In speaking of the duration of uncinariasis, we should clearly distinguish between the duration of cases which remain in the infected areas, and the duration of cases which after once becoming infected move to uninfested districts where conditions are such that reinfection is excluded.

In the former instance we have to deal with cumulative infection, taking place week after week and year after year, hence successive generations of parasites come into consideration.

In the latter instance we have to deal with the individual life of the parasites which are present in the patient at the time he leaves the infested area.

A failure on the part of most observers to distinguish between these two classes of cases renders the published data less valuable than they otherwise would be in determining the duration of uncinariasis.

In my own observations, I have found people remaining in the infested areas who gave a history of the disease extending back for ten, twelve, and even fifteen years. I have further three observations which I consider free from criticism in connection with patients who presented the disease six years (2 cases) and even six years and seven months (1 case) after being removed from the source of infection. I also have one observation, which is not free from criticism, upon a patient who showed the disease ten years after entering a hospital.

Sandwith (1894, p. 15) in discussing the duration of illness says —

“Nearly every patient said he had been ill two or three years before admission. I find among my notes 29 cases, uncomplicated by other diseases, where the patients said they had suffered more than three years. Of these, 13 had been ill for four years, 6 for five years, 3 for six years, 2 for eight years, 2 for nine years, 2 for eleven years, and one vowed it was fifteen years since the commencement of his symptoms.

“It may be safely said that during these long intervals of time very few patients had any rational treatment.”

It is probable that Sandwith's cases were subject to cumulative infections.

LENGTH OF LIFE OF THE INDIVIDUAL PARASITES.

It is already established that for every hookworm which is present in the intestine a separate embryo must enter the body. In other words, the eggs which the female worm deposits in the intestine will not develop there to mature parasites, but must first be discharged in the feces and undergo certain changes.

It is further clear that direct autoinfection, such as takes place in the case of pinworms (*Oxyuris vermicularis*), is excluded. For instance, suppose a child is at stool and soils his fingers with the feces, which contain hookworm eggs, then puts his fingers into his mouth and swallows the eggs; these ova will not develop in the bowels into adult worms.

Whether an *Uncinaria* egg, which happened to get under the finger nails, could reach the larval infecting stage in that place is perhaps an open question. So far as I am aware, the point has never been studied, but what is already known about this group of parasites does not lead me to believe that such a condition would be especially common, although it does not seem absolutely impossible.

With the foregoing premises in mind, it is important to determine how long the parasite in the intestine can live. Regarding the American hookworm, *Uncinaria americana*, I can present the following data: Of children at the Charleston Orphan Asylum in whom I demonstrated the presence of *Uncinaria americana* microscopically, it may be noted that 8 children had been in the orphan asylum two years or less; 4 children had been in the asylum between two and three years; 2 children had been in the asylum six years; 1 child had been in the asylum six years and seven months.

I have selected the Charleston Orphan Asylum as best fulfilling the conditions desired to illustrate the point at issue. The refined discipline, the scrupulous cleanliness, and the general hygienic conditions noticed are such that local infection is practically excluded. It must be admitted that some persons coming in from the country might possibly bring on their shoes a few embryos, but such a theoretical possibility is altogether too remote to explain the 15 cases found.

For all practical purposes we are justified in assuming that the hookworms which these 15 children had in them when I saw them were the same individual worms which were in the children when the latter entered the asylum, and from the data obtained it is clear that hookworms of the species *Uncinaria americana* are capable of living six years and even six years and seven months.

A sixteenth child (case of L. B.) examined showed a clear clinical history of uncinariasis of long standing. Her condition at the time of entering the institution, as described to me by Dr. Huger, and her present complexion, eyes, stunted growth, and inferior mental development leave no practical doubt in my mind regarding the diagnosis. No normal eggs were found in her stools, despite the fact that I made 25 slides. One slide showed a single abnormal egg which had evidently been dried and had clung to the slide after an examination in some other town. I do not know this girl's complete therapeutic history during the past twelve years, but from the absence of eggs in her stools it is necessary to conclude either that the worms had been expelled by the drugs taken or else *Uncinaria americana* is not able to live twelve years.

Ashford (see Stiles, 1902b, p. 210) mentions a case where a boy "had been the host of the worm for probably ten or fifteen years," but he does not state that during this time the patient was not exposed to further infection.

The clinical importance of the length of the life of the parasite is self-evident. Suppose a physician in the North has an anemic patient, or a physician in the South has an anemic patient who lives in the city or in a clay district; it is not sufficient to inquire whether he or she has recently been exposed to malaria, but inquiry should extend for eight or more years back in order to develop the fact whether she has

during this time visited any tropical or subtropical sand area. If such a fact does develop, uncinariasis is among the probabilities and a microscopic examination of the feces should be made.

GENERAL EXTERNAL APPEARANCE.

GENERAL LACK OF DEVELOPMENT—STUNTED GROWTH.

In severe cases of long standing the patient is undeveloped both physically and mentally. A boy or girl 12 to 14 years old may be as small as the average child of 6 or 8; a young man or woman of 18 to 22 years old may present the general development of a child 12 to 16 years of age, but the face may appear either like that of a child or like that of a very old person, especially like that of an elderly dwarf. Similar conditions have been described as a symptom of dirt-eating.

SKIN.

The skin has an anemic, waxy white to a yellow or tan, shriveled, parchment-like or tallow appearance. In general it is that color known in the South as a "Florida complexion." In some cases of malaria, if one trusts too much to the appearance of the skin, he is likely to be misled into an erroneous diagnosis of uncinariasis, but the general clinical history is usually sufficient to distinguish between the two diseases, while the microscopic examination gives a positive diagnosis. (See also, Temperature, p. 72.)

Wounds heal slowly.—Among the first severe cases of uncinariasis found, I noticed that several of the patients wore bandages. Suspecting the possibility of ground itch and recalling Looss's and Bentley's theories (see below), I immediately inquired into the history of the sores. According to the testimony of the patients the ulcers present had started as small wounds produced mechanically; the wounds had failed to heal promptly, had grown worse, and were now about a year old. This same story was related to me by quite a number of patients, and many other persons suffering from uncinariasis assured me that in their cases cuts and bruises healed very slowly, testimony which was repeatedly corroborated by local physicians.

Cutaneous lesions caused by uncinariasis.—The statements just made lead to a consideration of certain views recently advanced by Looss and Bentley.

Looss's theory of cutaneous infection.—Looss (1901) has shown that if a drop of water containing embryos of *Ancylostoma duodenale* is placed upon the skin an itching sensation is produced; the worms enter the hair follicles, and from there they seem to bore into the surrounding tissues. Looss further advanced the rather startling opinion that the larvæ then reached the intestine, and he recounted observations which gave a certain amount of plausibility to this view.

More recently (see Sandwith, 1902), Looss has performed experiments which, so far as can be judged at present, demonstrate the correctness of his theory. According to Sandwith (1902), Looss "smeared on the back of a puppy a mixture of charcoal and feces in which hookworm larvae had been bred. Between nine and ten days afterward the puppy died and was found to have anemia of most of his organs, and a plentiful supply of young hookworms was found in his jejunum. A second puppy was treated in a similar way and also died on the night between the ninth and tenth days. Upon post-mortem he also showed exactly the same results. A man who offered himself for experiment was also similarly treated on his forearm, and in his case the first hookworm eggs were discovered in his feces on the seventy-first day. In all three experiments the feces were regularly examined for some weeks prior to the experiments, so that, so far as we can now judge, the results must be accepted, despite their very startling nature. Furthermore, Looss is known as too careful an investigator to permit any foreseen error to creep into his conclusion.

Somewhat similar results, namely the entrance of embryos into the skin, have been obtained by van Durme (1902, pp. 471-474) in experiments with *Strongyloides stercoralis* on guinea pigs, and it is needless to insist on the great importance of Looss's demonstration.

Bentley's theory of ground itch.—In line with Looss's views, Bentley (1902a) has made certain exceedingly important observations and experiments, the logical conclusion of which, taken in connection with Looss's work, seems to be that at least certain forms of ground itch constitute the initial symptom of uncinariasis. Bentley defines ground itch as follows:

Ground itch—*Synonyms:* *Panighao*, *water itch*, *water pox*, *water sores*, *sore feet of coolies*—is an affection of the skin, confined entirely to the lower extremities, and probably always associated with the presence of the larvae of *Ankylostoma duodenale* in the soil of the affected areas; endemic in Assam and the West Indies and possibly present in other parts of the Tropics; characterized by its periodical epidemic appearance in the infected areas, coincident with the onset of the rainy season; with typical lesions consisting in a primary erythema, followed by vesicular eruption, which frequently becomes pustular and in severe cases may result in obstinate ulceration, or even gangrene.

Dr. Scheult (1900), of Trinidad, has suggested that the disease is probably due to some chemical irritant present in the soil, either natural or due to manure used in cultivation. Dr. Dalgetty (1901), of South Sylhet, struck by the resemblance which the lesions bear to scabies, and finding a mite present which he named *Rhizoglyphus parasiticus*, assumed this acarine to be the cause. These authors and Bentley (1902a) seem to agree that ground itch is a filth disease which

^aDuring the proof reading of the present report, Looss's (1903) article, detailing his brilliant experiments, has appeared. He demonstrates, beyond any question of a doubt, the correctness of his contention that infection with hookworms may take place through the skin.

is increased by the lack of care given to the proper disposal of alvine discharges.

Bentley (1902a) found in a water sore a young worm which he considered to be identical with *Agchylostoma duodenale*. He then performed the following experiments—

a. Some ordinary soil was sterilized by heat, and after being moistened with sterilized water, was infected with a small quantity of fecal matter containing numerous ova of *Agchylostoma duodenale*.

b. A similar preparation of soil was infected with a small quantity of feces, which on examination was found to be free from hookworm infection.

These two preparations were incubated at the ordinary temperature of the air for about a week, when sample “*a*” was found to be swarming with larval hookworms and various forms of bacteria and fungi, and sample “*b*” was similar in appearance except that no hookworm larvæ were found.

Each sample was then divided into two parts, *a'* and *a''* and *b'* and *b''*. Samples *a'* and *b'* were kept moist, while *a''* and *b''* were gently dried by exposure to the air for eight hours. Previous experiments had shown that six hours gentle drying at ordinary temperatures was sufficient to kill the hookworm larvæ. After remoistening *a''* and *b''* with sterilized water, the four samples were applied to the wrists of the subjects of experiment for eight to nine hours, and then they were removed. Fifteen hours after the first application, considerable erythema with a minute papular eruption appeared over the spot to which *a'* had been applied; within twenty-four hours a distinctly vesicular eruption had developed, followed by pustules exactly resembling those found in the lesions of ground itch. In the other cases a faint reddening of the skin was produced, which shortly afterwards disappeared. A reexamination of sample *a'* now showed that no live larvæ were present, although one or two dead worms were found. Sample *a''* still contained the dead larvæ. Apparently, therefore, the live larvæ *a'* had entered the skin and their entry had been followed by lesions similar to those found in water sore.

According to Bentley, also, it is probable that the acuteness of the inflammation attending an attack of the ground itch is largely governed by the nature of the organisms which accompany or follow the larval hookworms in their passage through the skin.

Regarding the treatment of ground itch, Bentley says that in the papular and early vesicular stage of the disease the application of a strong solution of salicylic acid in collodion or methylated spirit will cause the eruption to dry up, and so cut short the attack of the disease to one or two days. If, however, pus has formed, the only treatment of any service is the opening up and disinfection of the pustules with pure carbolic acid, silver nitrate, or nitric acid, and the after treatment of the sore as an ordinary ulcer. In cases attended with great swell-

ing, inflammation, and tendency toward the formation of sloughs, free skin incisions and the use of hot antiseptic footbaths are indicated.

Dalgetty (1901, p. 77) advises the application of a strong solution of lime and sulphur; strong phenyl solution is also beneficial, and a coating of coal-tar acts for a time as a preventative against infection; but when once the vesicles have formed pustules are sure to follow, and then the only remedy is to open them, evacuate the pus, and thoroughly cleanse them.

An anonymous writer (! Dr. Elliot, of Assam) in the *Journal of Tropical Medicine* (1900), gives the following directions:

"The indications are to get the case as soon as possible; to carefully cleanse the foot by soaking it in warm antiseptic solution; then open the vesicles with sharp pointed scissors, snip the loose skin away, and finally wash the parts with carbolic acid solution (1 in 40), and treat the resulting ulcer with carbolic acid, phenyle oil, extract of paroli leaf, zinc ointment, etc., according to circumstances. The soaking, washing, and dressing operations are repeated once or twice daily, and healing takes place in eight or nine days in favorable cases."

It will be noticed that Bentley does not definitely state that he adopts Looss's view of intestinal infection through the skin; nor does he definitely state that the hookworm larvæ act as anything more than carriers of bacteria. The conclusion would therefore seem to be that the ground itch with which he was dealing is a bacterial infection due very probably to fecal bacteria." If this interpretation is correct, its *dependency* upon uncinariasis does not seem to be proved, although its occurrence with the disease would seem to be established.

Additional facts (besides Bentley's experiments) which support the view that the ground itch, with which he was dealing, is more or less connected with hookworm infection are the following:

Ground itch occurs in the warm rainy season, especially in June, July, August, and September, and does not occur in cold weather, even when it rains; thus the seasonal distribution in general agrees with the infection period of uncinariasis. Grass-covered soil and smooth beaten roads do not cause it, neither does working in loose dry soil; and these conditions are unfavorable to the development of uncinariasis. The number of cases increases after a heavy rain and rapidly decreases during a hot spell, a fact which agrees with the biology of hookworms. "The soil itself is sandy, with clay here and there; a belt of pure sand, 40 to 60 feet thick, lies at a depth of 6 to 18 feet from the surface;" and uncinariasis is preeminently a sand disease.

Still the question is not quite so simple as would at first appear, and in connection with the subject the following points come up for consideration:

"Looss has, however, proved that certain cutaneous symptoms follow the entrance of hookworm larvæ into the skin:

1. According to Bentley, ground itch is confined entirely to the lower extremities, and other authors state that it rarely extends above the ankles. According to the physicians in Georgia and Florida, it is found on other parts of the body also. I saw one case, said to be typical, where the disease was confined to one arm. Under these conditions is the panighao, discussed by Bentley, identical with the so-called "ground itch" which is so common in the southern portion of the United States, or is only a part of the American "ground itch" produced by hookworm larvæ?

2. If ground itch is the initial stage of cutaneous infection with uncinariasis (as Looss's and Bentley's views would seem to indicate), why should it be confined entirely to the lower extremities? If infection by uncinariasis frequently takes place through the skin, would not the hands and arms also, especially of children, and more particularly the soles of the feet and the palms of the hands, the spaces between the toes and fingers, and under the toe nails and finger nails, be the most common initial points of ground itch in case this latter is an initial symptom of uncinariasis?

3. On the same premises would we not commonly find lesions corresponding to ground itch on the abdomen of cattle, sheep, goats, dogs, cats, foxes, seals, and other animals suffering from uncinariasis? I will not deny that such lesions occur, but I have seen many cases of hookworm disease in certain of these animals and I have no recollection of having observed anything which corresponded to ground itch. If it were as prominent, in the animals named, as the typical "ground itch" of man which I saw in Georgia, I doubt whether I should have overlooked it. Possibly I did not have recent infections before me.

4. According to the testimony of Georgia and Florida physicians "ground itch" is exceedingly common; it occurs at some period in the life of practically every person, unless he lives exclusively in the city; it occurs in the healthy as well as in the sickly, and in persons who neither at the time of infection nor later show the slightest evidence of anemia. These statements, which I have repeatedly heard from Southern physicians, can not be said to indicate that Bentley's views are applicable to all cases of "ground itch" as we find this disease in this country.

5. "Ground itch" is said to be common in clay districts as well as in sand districts. Under these circumstances, why is uncinariasis so pre-eminently a disease of the sand areas?

6. Bentley states that "ground itch" is probably always associated with the presence of the larvæ of *Agchylostoma duodenale* in the soil of the affected areas. Doubts may, however, arise as to whether a sufficiently wide geographic range has been examined in connection with this point.

In view of the above considerations, it will be well to remain open

to conviction awaiting a more thorough demonstration of the broad application of Bentley's interesting and valuable views. But until better proof is advanced than has thus far been brought to my attention, I find it impossible to unreservedly adopt the opinion that American ground itch is *necessarily* connected with uncinariasis.

While not opposing the theory of infection through the skin, but admitting, on the contrary, that Looss has proved his point, I may state that the conditions which I saw in the southern portions of the United States do not indicate that any indirect method of intestinal infection is necessary in order to explain the severe cases of uncinariasis observed. The average boy or girl suffering from this disease is not conspicuous because of personal cleanliness. Bath tubs are not found in their homes, and from physical examinations I made I can testify that not only their hands and finger nails, but their entire bodies also, are far from a condition unfavorable to parasitism. Sucking the fingers, picking the teeth, biting the finger nails, or even eating a piece of bread with soiled hands will usually suffice to convey some dirt between the lips. The sand on which the children play must be heavily infested with hookworm larvæ, and it certainly can not be an exceptional occurrence that the children unconsciously carry microscopic worms to their mouth. Further, the chances for infection of surface wells, from which the drinking water is taken, are very great in any sandy soil. If, however, cutaneous infection were the rule, I should expect to find all barefooted children in the infested area suffering not only from ground itch the entire summer, but also from severe infections of hookworm disease.

Hair.—The hair on the head appears to be about normal, but in cases contracted before puberty, the beard and the hair on the body (pubis, armpits, arms, legs) are usually undeveloped. I have seen patients 20 years of age upon whose body hairs were almost absolutely lacking.

Breasts.—The breasts of females, who have contracted hookworm disease before puberty, remain more or less undeveloped. In a girl of 20 years of age, for instance, the breasts may not be developed beyond those of a girl of 8 or 9 years old.

Nails. The color of the tissue directly under the nails varies with the anemia.

HEAD.

Face. The face has an anxious, stupid expression, and in severe cases is more or less "bloated" (edematous).

In fact, a prominent symptom of uncinariasis in practically all animals in which it occurs is the development, in severe cases, of a more or less extreme edema. To use the rural vernacular, "the face bloats," and "the feet and ankles swell." The symptom in question is more or less irregular in man as it is in other animals, notably in sheep, appearing and disappearing at intervals. Upon several occa-

sions I was informed that this symptom interfered seriously with the school attendance, for if the children sat still a long time in school "they began to swell." Quite generally, as was to be expected, testimony was to the effect that the edema was less frequent in the winter than in the summer.

Eyelids; conjunctivæ.—An examination of the eyelids exhibits the visibility of the blood vessels in light cases, but an absolute marble whiteness in very severe cases, with all possible intermediate stages corresponding to the general degree of anemia.

Eyes.—While looking at the eyelids for anemia, the observer frequently notices that the pupils are dilated or that they dilate readily and that the eyes are dull, dry, and usually of a chalky white. If the patient is directed to stare intently into the observer's eyes, there will be noticed a symptom which it is difficult to describe, but which I have found more constant than almost any other noticed, namely: After a moment, the length of time *apparently* varying slightly according to the degree of the disease, the pupils dilate and the patient's eyes assume a dull, blank, almost stupid, fish-like or cadaveric stare, very similar to that noticed in cases of extreme alcoholic intoxication. I am not familiar enough with the stare of anemic patients in general to state how common this peculiar look is among them, nor have I found any of my medical friends who could give me much information on this subject; but I can state that among the several scores of anemic people whom I examined on this trip, in the severe cases with two exceptions, I found the eggs of *Uncinaria americana* in every one (whose feces were examined) in whom I observed that indescribable stare; the two exceptions in question were city boys, both of them sons of a confirmed inebriate; further I failed to find the eggs present in certain extremely anemic patients in whom the stare was not noticed. It certainly was absolutely absent from a number of typical cases of malaria. Toward the end of the trip, I found myself unconsciously relying more upon the presence or absence of the blank stare than upon any other single symptom, except of course the presence of the eggs in the stools.

I will not go to the extent of stating that this stare is diagnostic for uncinariasis (and I will even warn that in dark eyes it is less evident than in eyes of light color), for I do not feel that I have had experience enough with the peculiarities of eyes in various diseases to speak authoritatively upon the subject. I simply mention this peculiarity in connection with the discussion of the eye as a symptom which, as my investigations progressed, made more and more of an impression upon me. Upon calling the attention of several local physicians to this peculiar stare, they informed me that it was a totally new symptom to them, but that after examining several cases they found it a very prominent symptom. As a general rule the eyes in advanced stages are dry. In this connection it may be noticed that several

authors have mentioned the glassy appearance of the eyes of dirt-eaters.

Since my return, several of my clinical friends with whom I have discussed this symptom have expressed some skepticism in regard to the matter. Although thoroughly convinced of its existence, for I saw it too frequently to be deceived, I have written to several Southern clinicians requesting them to give me the benefit of their independent observations on this point.^a Up to the time of reading "galley proof" of this report the following replies have been received:

[Extract from a letter from Dr. Hilsman, January 2, 1903.]

"Replying to your letter, 24th ultimo, I have to say that I have examined the patients that we saw in the country, and on making them gaze intently at me as you directed, I observed the vacant stare that you described, but did not observe the dilation of the pupils. The stare is very much like that of an epileptic as he begins to recover from a fit.

"These cases have improved under treatment suggested by you. The little girl passed a large number of the worms."

[Extract from a letter from Dr. M. A. Clark, January 30, 1903.]

"I have delayed, hoping to find the eye symptom you mention, but I have not yet found it. My cases are improving slowly."

Dr. James Edward Stubbett, of New York, who spent some years in Central America and has seen many cases of hookworm disease, has stated to me that he has frequently observed the peculiar stare in the eyes of dirt-eaters.

In this connection it is also not uninteresting to note that some "worm doctors" claim to lay special stress upon the eye in making their diagnoses; also that dilation of the pupil, due to irritation by intestinal worms as well as to anemic conditions, is recognized by certain prominent writers on the eye; further, that dilation of the pupil is also a symptom upon which many children's nurses depend in suspecting the presence of worms.

Sandwith (1894, p. 12) states that the eyes of his patients showed a pearly white conjunctiva, singularly in contrast with the yellow color of the face. Dr. Scott examined several men for him with the ophthalmoscope, and found in half of them a normal fundus, and in the other half a very pallid fundus. The refraction tests showed astigmatism in many cases.

Nostrils.—The visible mucous membrane of the nostrils becomes pale in proportion to the anemia.

Lips and gums.—The lips also become pale in proportion to the anemia, the inner surface of the lips and the outer surface of the gums frequently presenting almost a chalky white appearance.

Teeth. Irregularity of the teeth was so common among patients affected with uncinariasis that the question arose in my mind whether this was not to some extent an expression of the general underdevel-

^aMore recently I have repeatedly found this peculiar stare and have demonstrated it to several clinicians.

opment of the body due to this disease. The point at issue calls for the opinion of a dentist rather than that of a zoologist. The decayed teeth of dirt-eaters have been recorded in early writings on this habit.

Tongue.—In some cases the tongue was coated. A number of observers have already called attention to this symptom, which was by no means general in the cases I observed.

Several authors have remarked upon the presence of black, brown, or purple spots on the tongue in cases of uncinariasis, and the view has been advanced that these present a valuable aid in diagnosis, and in some cases, at least, that they disappear on treatment. In the cases which came under my observation, I looked very carefully for this symptom. In many instances I found more or less distinct purplish to brownish spots, irregularly round or elongate in shape, and these may or may not be identical with the spots described by the authors cited. It was, however, noticeable that in many cases where these spots were observed, the patients were accustomed either to chewing tobacco or to dipping snuff. In fact, some of the spots in question I am inclined to refer to the use of tobacco or snuff. Whether all cases are to be explained in this way is, however, open to question, with probabilities against such explanation. Nevertheless, it is well for practitioners to be forewarned upon this chance of error in diagnosis. Several authors have assumed that the spots on the tongue represent a symptom which has only recently been observed in this disease. In this connection, it is interesting to note that early authors—for instance, Cragin (1836a) and Imray (1843)—in writing upon dirt-eating have described these same spots.

NECK.

The cervical pulsations are often very evident, and in some cases may be seen from 6 to 12 feet away. (See Circulatory system, p. 72.)

THORAX.

In emaciation the thorax corresponds to the general emaciation of the extremities. In some cases the ribs are very prominent..

Heart.—See page 72.

Breasts.—See page 64.

ABDOMEN.

“Pot-belly” or “buttermilk-belly,” dropsy, and tympanites.—The condition known as “pot-belly” or “buttermilk-belly” is exceedingly common in uncinariasis, especially in extreme cases in summer. It is a distension of the abdomen, due apparently to two factors: (1) a gaseous distension of the bowels, and (2) the presence of an excess of fluid in the abdominal cavity.

I hasten to add that I have not seen a single autopsy in man infected with uncinariasis, but the same abdominal distention is found in

animals suffering from this disease, and a number of post-mortem examinations, especially on sheep, have given the conditions described.

Lutz mentions flatulence of the lower abdomen as a common symptom, and Sandwith (1894, p. 11) found it present to a slight extent in one-third of the cases.

Hair.—See page 64.

Genitalia.—See page 78.

EXTREMITIES.

Nothing of any particular note was observed in connection with the bones; for the muscles see p. 73. In many cases the feet and ankles were swollen, and in several cases the legs were marked with ulcers. See p. 59.

According to Sandwith (1894, p. 12), edema of the legs, like albuminuria, is to be seen only in the worst cases, and some of these had general edema when admitted in a dying condition.

GENITALIA.

See page 78.

MUCOUS MEMBRANES.

All mucous membranes correspond, in respect to their color, to the grade of anemia. (See Eyelids, p. 65; nostrils, p. 66; lips and gums, p. 66; tongue, p. 67; genitalia, p. 78.)

EXCRETIONS AND SECRETIONS.

URINE.

I have no observations to record in regard to the urine. Sandwith (1894, p. 11) states that—

“The urine is not unlike that of ordinary anemia, neutral or alkaline in equal proportion, and rarely acid, pale colored, with specific gravity ranging from 1010 to 1015. A trace of albumen was present in all the most advanced cases, without casts under the microscope.”

According to Zinn and Jacoby (1898, p. 16), Lussana (1890) found in the urine of patients suffering from uncinariasis a poisonous substance of the nature of a ptomaine, which caused extensive changes in the rabbit's blood, especially a change in the number of red blood corpuscles, and also poikilocytosis. These results are said to have been confirmed by Arslan (1892).

FECES.

Consistency.—The feces may be hard or soft, according to the presence of constipation or diarrhea.

Reaction.—In reaction the feces may be acid, alkaline, or neutral.

Color. In a large proportion of medium and severe cases, the feces are reddish to brown in color. In some cases blood is present.

Blotting paper test.—In about 8 out of 10 medium and severe cases, if a portion of the feces is placed upon white blotting paper, and allowed to remain there for twenty minutes to several hours, it leaves on the paper a reddish brown stain similar to a blood stain. This test will be found useful by physicians who are not prepared for microscopic tests.

Microscopic examination.—If feces less than twenty-four hours old are examined microscopically, the eggs will be found in various stages of segmentation. If feces over twenty-four hours old are examined the free embryos also are usually found. If free embryos are found in perfectly fresh feces, the diagnosis of infection with the worm (*Strongyloides stercoralis**) of Cochin-China diarrhea must be made, and this parasite we may find in the same patient in whom uncinariasis is present.

CIRCULATORY SYSTEM.

The symptoms of the circulatory system are the most marked and most common; they seem to develop after the symptoms of the digestive system, but before those of the nervous system.

ANEMIA.

In all medium and severe cases, the anemia is what first attracts attention. This varies in intensity not only in proportion to the degree of infection, but also to a considerable extent in proportion to the length of the period of infection. For instance, 100 worms may be expected to produce a greater anemia within a given time, say one year, than will 50 parasites. But 50 worms may be expected to produce more anemia in two years than in one.

In some medium cases, the blood vessels of the conjunctivæ may be more or less visible, and the visible mucous membranes of the nose, mouth, and vulva, may be more or less of a normal or subnormal color. In the extreme cases, these structures may be as white as marble or paper. In the same way the color of the skin will vary (see Skin, p. 59; Nails, p. 64) from an almost natural hue to a whitish, lemon yellow, or tan color.

*This worm is probably much more common in this country than supposed. The cases known to me to date are: Baltimore, Md.—1 case, 1 death; reported by Strong, 1901. Richmond, Va.—1 case, 0 death; reported by Thayer, 1901. Anne Arundel County, Md.—1 case, 0 death; reported by Thayer, 1901. Washington, D. C.—4 cases, 0 death; unpublished, Zool. Lab., U. S. Public Health and Marine-Hospital Service. Ohio—1 case, 0 death; unpublished, Dr. A. P. Ohlmacher (mentioned here by kind permission of the observer). San Francisco, Cal.—3 cases, ? deaths; unpublished, Dr. P. K. Brown (mentioned here by kind permission of the observer). Cuba—? cases, ? deaths; unpublished, Dr. John Guiteras (mentioned here by kind permission of the observer). Porto Rico—? cases; ? deaths; unpublished, Dr. P. K. Brown.

Blood.—I did not stop for blood counts, as these have been made by other men, and while they are exceedingly interesting from a pathological standpoint they have not appealed to me as so direct a method of diagnosing intestinal parasites as is the fecal examination. In general it may be said that the blood of man corresponds to the blood of sheep, goats, cattle, dogs, etc., suffering from the same disease; in other words, the severer and longer the infection, the thinner the blood. In the vernacular of the sandlapper, it is "like water." It may here be added that in early literature on dirt-eating, several authors remark upon the water-like appearance of the blood.

Speaking in more technical language, the blood has been shown by Ashford to possess the following characteristics:

"(1) A severe anemia, falling as low as that of Addison's anemia in count of red cells in some cases. (2) A very low hemoglobin average and a very low color index. (3) A marked eosinophilia in some cases; 40 per cent reached in one case. This follows the observation of Neusser. (4) No leucocytes common to the disease itself. Leucocytosis recorded is always apparently due to complications, as noted. (5) Frequent presence of normoblasts, and in some cases megaloblasts, but never a majority of megaloblasts. (6) Poikilocytosis common. Manson denies this."

Ashford gives the following interesting table of blood counts:

Date.	Current number.	Red cells.	Hæmoglobin.	White cells.	Percentage of polymorphonuclear leucocytes.	Percentage of small lymphocytes.	Percentage of large lymphocytes.	Percentage of eosinophiles.	Normoblasts per cubic millimeter.	Megakaryoblasts per cubic millimeter.	
November 4 ...	1	1,530,116	20	6,800	65	21	9	5	26	13	Poikilocytosis. Polychromatophilia, many microcytes and macrocytes. Treatment: Digitalis and peritomanagan. Recount, November 23, 1899: Hæmoglobin, 16 per cent; red cells, 1,890,000.
November 8 ...	2	697,776	20	7,960	59	17	15	9	144	46	Poikilocytosis. Polychromatophilia, many macrocytes and microcytes. Treatment: Pil, ferri, quin, et strychni, and pil. arsenic. Recount, November 23, 1899: Hæmoglobin, 23.5 per cent; reds, 2,664,440.
November 4 ...	3	1,533,112	22	2,000	61	22	8	6	8	0	Poikilocytosis. No rouleaux. Treatment: Digitalis and peritomanagan. Recount, November 23, 1899: Hæmoglobin, 23 per cent; reds, 1,373,328.
November 5 ...	4	1,200,000	15	4,200	64	23.4	6	6.6	109	8	Poikilocytosis. Polychromatophilia. Treatment: Digitalis, sirup, ferri iodidi. Recount, November 23, 1899: Hæmoglobin, 17.5 per cent; reds, 801,104.
November 6 ...	5	1,484,440	10	6,000	64	24	8	4	12	0	Poikilocytosis. Slight tendency to rouleaux formation; macrocytes and microcytes, latter predominate over former. Recount, November 23, 1899: Hæmoglobin, 14 per cent; reds, 687,776.
Do.	6	2,193,328	23	8,800	65	26	8	14	123	35	Poikilocytosis. No tendency to rouleaux formation. Treatment: Digitalis, pil, ferri, quin, et strychni.
November 7 ...	7	1,633,328	17	5,600	60	23	5	12	11	0	Poikilocytosis. Many macrocytes and microcytes. Slight rouleaux formation; marked chromotaphilia. Treatment: Digitalis, liq. potas. arsenitis in increasing doses to grt. 5 t. i. d.
Do.	8	2,064,664	23	4,800	74	17	6	3	28	0	Poikilocytosis. Rouleaux formation good. Treatment: Pil, ferri, quin, et strychni, and digitalis. Recount, November 23, 1899: Hæmoglobin, 31 per cent; reds, 3,084,440.
Do.	9	1,271,104	14	7,800	60	17	6	17	30	15	Has elephantiasis arabum, but I can not identify the filaria as yet. Microcytes predominate over macrocytes. Good rouleaux formation. Treatment: Peptomanagan. Recount, November 23, 1899: Hæmoglobin, 24 per cent; reds, 2,520,000.
Do.	10	1,600,000	17	1,500	72	20	4	4	6	0	Poikilocytosis. Recount, November 23, 1899: Hæmoglobin, 13 per cent; reds, 668,888.
November 8 ...	11	1,800,000	25	4,600	59	22	7	2	9	0	Poikilocytosis. Rouleaux formation good.
Do.	12	2,266,636	20	7,680	52	26	12	10	0	0	Rouleaux formation slight; has abscess of the liver.
November 9 ...	13	1,268,888	20	6,800	63	17	7	13	0	0	Poikilocytosis. Rouleaux.
Do.	14	2,440,000	25	11,000	50	10	9	31	0	0	Tertian malarial parasites found. Rouleaux good.
Do.	15	2,353,328	17	12,700	73	17	4	6	10	10	Poikilocytosis. Rouleaux good. I believe this man to have been suffering from pneumonia at the time of examination, although the differential seems strange.
Do.	16	2,934,444	...	5,200	72	20	8	40	36	0	(Only case not presenting ankylostomes. Has tuberculousis.
November 10 ...	17	2,140,000	23½	18,000	40	12	8	40	0	0	Poikilocytosis. Rouleaux formation good.
November 20 ...	18	3,524,440	55	14,800	88	9	3	1.5	0	0	
November 12 ...	19	1,560	30	9,000	60	16	10	10	125	...	
November 20 ...	20	1,560,000	16	2,400	72	10	5	13	0	0	

a Unknown.

Cervical pulsations.—In the rural vernacular, “jerking at the neck” or “jumping at the neck” refers to an anemic symptom which is exceedingly prominent in most medium cases and in all extreme cases of uncinariasis. It is simply the violent pulsations of the cervical vessels, visible sometimes at a distance of 2 to 4 meters.

Heart.—Nearly all medium and severe cases complain of having “heart disease” or a “fluttering of the heart,” and many of the patients are taking medicine for this symptom. (See also p. 35.) We have here, of course, the usual cardiac symptoms of an extreme anemia.

“Palpitation over the heart, in the epigastrium, and in the temporal arteries is sure to be present in bad cases, while the anemic murmurs of heart and neck are solely dependent upon the degree of anemia, and can be banished by a prolonged course of iron. Hypertrophy of heart was noted and verified after death in some of the advanced cases.” (Sandwith, 1894, p. 12.)

Pulse.—Pulse varies from 80 to 132 per minute. In medium and severe cases I noticed about 120 per minute probably more frequently than either a higher or a lower pulse. This was found in young and middle-aged (probably more commonly in children), in males and females, and yet without a temperature which was distinguishable by the hand as especially high.

TEMPERATURE.

Not being able to follow any cases for any length of time, hence not being able to make continued observations on the temperature, I considered that observations in other lines were more important under the circumstances. Hence I did not take temperatures carefully. According to observations by various clinicians, there may be subnormal or normal temperature, or the thermometer may register 100° to 102° F.

“The skin is always cold, and the temperature before thymol generally subnormal in uncomplicated cases. After excluding any fever produced by concurrent diseases and any defervescence caused by thymol, I find that one-third of my patients had a normal temperature during their stay in the hospital, but that two-thirds had a distinctly subnormal range, varying from an average of 36.3° C. a. m. to 36.9° C. p. m.

“Many of these patients when convalescent had an increase of half a degree, night and morning.

“Surgeon-Major Giles suspected that many of his patients in Assam had suffered from fever at the onset of their malady, and he was confirmed in this impression by observing pyrexia in the monkeys he fed on anchylostoma embryos. After eliminating all those who had fever in the hospital, or a history of intermittent fever or any enlargement of the spleen, I found that 68 per cent of the remaining stated that their trouble had begun with a few days’ fever.” (Sandwith, 1894, p. 12.)

RESPIRATORY SYSTEM.

NOSTRILS.

See page 66.

RESPIRATION.

Many patients complain of a difficulty in breathing, especially after exertion. This symptom is quite natural, in view of the low condi-

tion of the blood and the emaciation of the muscles. Respiration is rather variable and does not appear to be a symptom of very great value; it may be slow, or it may be increased to about 30 or more per minute. According to Sandwith (1894, p. 12) dyspnea and noises in the ears were present, as might be expected with marked anemia.

MUSCULAR SYSTEM.

EMACIATION.

A progressive emaciation is more or less common, especially in severe cases. The arms and legs seem to be reduced to skin and bones; the chest is so emaciated that the ribs are very prominent and the beating of the heart is very evident. What little muscle is left is soft and flabby.

Emaciation is, however, not present in all cases, and even in some medium infections the muscles may be well formed and more or less hard. I recall one case in particular: A boy about 14 who showed a heavy infection microscopically, a clear clinical history of uncinariasis of several years standing, decided anemia, distinct cervical pulsations, abdomen rather distended ("pot-bellied"), yet his arms and legs were well formed and his muscles surprisingly solid for a patient in his condition.

Sandwith (1894, p. 13) found the average weight of 100 grown men upon admission to the hospital to be 117.5 pounds; the average height of these men was 5 feet 5.5 inches, which by Dawson's tables should scale at least 135 points. Of the patients who stayed in the hospital more than two weeks 70 per cent gained weight, 22 per cent lost, and 8 per cent remained stationary. The average loss of weight was 3.2 pounds, and was, of course caused by the necessary starvation, thymol, and purging. The average gain was 5.4 pounds, some patients gaining as much as 15, 17, 18, or 20 pounds.

GREAT PHYSICAL WEAKNESS.

One of the most pronounced symptoms complained of is a general weakness. The patient states that he is obliged to rest after exertion. In light cases a feeling of lassitude is experienced without being able to assign it to any particular cause; as a result, it is generally assigned by other people to laziness. In medium cases the patient may be able to work one to three or four hours before becoming exhausted; in very severe cases he will scarcely be able to walk across the room, or he may be confined to the bed for weeks at a time. A physical examination usually shows an emaciation proportionate to the weakness.

DIGESTIVE SYSTEM.

LIPS, GUMS, TEETH, AND TONGUE.

See p. 66.

NAUSEA.

Nausea was not noticed. Sandwith (1894, p. 11) states that vomiting and nausea are rarely complained of.

APPETITE.

The appetite may be light or ravenous. According to Sandwith, the appetite is invariably affected, sometimes ravenous at beginning, but later always capricious and diminished. The English nurses report to him that the patients were always begging for medical comforts or cigarettes, even in the middle of the night, when other patients were asleep. Among 40 men carefully examined, 16 said that their appetite was once greatly exaggerated, 16 pleaded diminution from the beginning of their illness, and 8 believed that their appetite was normal until the anemia became very marked.

Perverted appetite, "Dirt-eating."—The most important point to be noticed in connection with the appetite is the abnormal desire for some particular article of food. Frequently this is a preference for something sour or bitter.

Many patients with uncinariasis are known throughout the village or county as being especially fond of pickles. I have seen boys and girls in advanced cases of this disease who would greedily devour an entire bottle of pickles. Some patients are especially fond of sucking lemons, or lemons and salt, or salt alone. Others are known for their desire to chew coffee, or to drink large quantities of strong coffee without milk or sugar. Some are abnormally fond of buttermilk. Others are noted as "resin-chewers." Some are accused of "lapping sand." Many are accused of eating clay or dirt.

Dirt-eating has been discussed by a number of authors, opinion being divided as to its status. Some writers look upon it as the cause of the disease; others view in the habit only a symptom or a result; still others consider it nature's treatment of a diseased condition.

Among helminthologists there seems to be the impression that dirt-eating is especially likely to lead to infection with parasites. Among Southern physicians I found the idea quite prevalent that dirt-eating was one of the causes of the condition which I have classed as extreme uncinariasis.

During the trip now under discussion, I have had opportunity to observe many so-called dirt-eaters. As most authors state, it is exceptional that one will acknowledge that he eats dirt. I believe the explanation of this denial is very clear, namely, not only is there a certain amount of disgrace connected with the reputation of being a dirt-eater, but probably not over one person in ten, or possibly

in twenty, accused of eating dirt ever does so. The other nine to nineteen have their abnormal appetites developed in a different direction, namely, pickle-eating, lemon-sucking, coffee-chewing, resin-chewing, etc.

Among the articles eaten by these "dirt-eaters," various authors mention charcoal, chalk, dried mortar, mud, clay, sand, gravel, stones, shells, rotten wood, cloth, garments, paper, tobacco pipes, mice, young rats, etc.

It is, I believe, an error to attempt to reduce this abnormal habit to any one common basis. In general, however, it may be stated that the alleged "dirt-eating" in this country practically represents the severe cases of uncinariasis. To attempt to reduce dirt-eating to infection with worms, particularly with *Uncinaria americana*, will doubtless be thought extreme, more particularly by Northern physicians. Still the idea is not a new one, and a moment's consideration will show that this view is far less extreme than it at first appears.

For an excellent general discussion of dirt-eating, with extensive references to literature, the reader is referred to Le Conte (1845). For the purpose of the present paper it will suffice to call attention to certain facts and analogies. The habit of eating slate pencils, paper, and other objects by chlorotic girls is more or less commonly known. Pregnant women, also, may develop an abnormal appetite, which takes different phases, including dirt-eating. It is recorded that the Javanese women eat certain dirt in order to improve their appearance. In certain localities in tropical America (Orinoco) the natives eat earth during the overflow of the river when they can not obtain their regular food. Earth eating is said to be common and not injurious in certain parts of Africa. According to Sandwith (1894, p. 9), on the day of the maximum high Nile, and the general rejoicings thereupon, the town crier, who is on the lookout for backsheesh, presents "teen ibliz" (Nile mud) with a lemon to the inhabitants for luck, and many of them eat of it. Dogs, horses, cattle, hogs, and alligators are recorded as eating clay and sticks. The Alaskan seals, when infected with round worms, eat pebbles. Elephants, when infected with flukes, eat a certain kind of clay until a looseness of the bowels is produced. I have frequently heard Texas grangers attribute the death of cattle to eating sand, and in post-mortem examinations of cattle, sheep, and goats, in an anemic condition from intestinal worms (verminous gastritis caused by *Hæmonchus contortus*, *H. Ostertagi*, etc., and infection of small intestine with *Uncinaria trigonocephala* and *U. radiata*), I have repeatedly noticed in the stomach and intestine large quantities of sand; so that the farmers present declared that this was the cause of death. Dogs infected with intestinal worms eat grass. Cats also frequently eat grass, probably from the same cause. Children infected with eel worms (*Ascaris lumbricoides*) are known to

occasionally eat dirt, and I know of one such case where the habit ceased when the worms were expelled.

In view of the comparisons cited, it would seem that the idea of considering dirt-eating as a manner of infection with parasitic worms, although conceivable for some cases, is hardly correct as applied to most instances. That dirt-eating is an abnormal appetite due to a diseased condition (anemia and a disordered digestive system) as suggested by several authors as early as the first half of last century, seems to me to be an explanation of much more general application; and that this anemia and enteritis or gastritis may be produced by parasitic worms is an established fact. In this connection, it is interesting to note that Hancock (1831, p. 67), in discussing dirt-eating, mentions "worms preventing the nourishing effects of food;" Inray (1843, p. 310) remarks that "worms in considerable numbers were not uncommonly accumulated in the intestinal canal." Further, it is significant that various authors, in discussing the treatment of dirt-eating, attribute more or less success to certain drugs which are in fact used more or less in treating for intestinal parasites. Thus, Cotting (1836a) refers, as stated above, to the decrease of dropsy and of dirt-eating corresponding to the more general use of calomel; sulphate of iron is mentioned by Cragin (1836a), Pollard (1852), and others; according to Pollard (1852), copperas is a popular and successful remedy among the negroes; Hancock (1831) refers to a remedy containing arsenic as having had great success; Jordan (1832) states that dirt-eating decreased upon destroying the huts and moving the families to some other location.

To summarize: While it would seem decidedly extreme and unwarranted to maintain that dirt-eating is necessarily an indication of infection with intestinal worms, still I believe the conclusion is justified that it is undoubtedly a more or less common tendency in such infections, not only in man but also in other animals. It may be classed with the chewing of slate pencils, resin, coffee, sucking of lemons and salt, etc., as an abnormal appetite due to the anemia and abnormal condition of the intestinal tract. Further, for all practical purposes it is not much of an exaggeration to look upon most, if not all, so-called dirt-eaters of the sand areas of our Southern States as representing severe cases of uncinariasis.

Sandwith (1894) states that 26 per cent of his patients confessed to eating earth, and he refers to "earth hunger" as sometimes the cause and sometimes the effect of hookworm disease.

PAIN IN THE STOMACH; INDIGESTION.

Many patients complain of colicky pains "in the stomach," and will indicate the region between the navel and the ensiform cartilage as the seat of the "misery." Indigestion is frequently mentioned, and the tongue is occasionally coated.

Just how much the indigestion is due to uncinariasis and how much to other causes may be considered an open question. Foul breath is mentioned by some authors as a common symptom of uncinariasis, but this has not been particularly noticeable in many of the cases I saw.

Many authors explain the tendency to dirt-eating as an effort to neutralize the hyperacidity of the stomach. As I have just shown (p. 74), however, many patients with uncinariasis eat pickles and suck lemons.

According to Sandwith, a gnawing, throbbing pain in the epigastrium is the first symptom complained of, chiefly because it is constant, whereas a severe colic and borborygmi (rumbling of bowels caused by gas) of intestine are present from time to time. I was unable to confirm the constancy of the pain.

CONSTIPATION AND DIARRHEA.

Sandwith (1894, p. 11) states that when the patient is not under thymol and purgative treatment, constipation is a very constant symptom in hospital cases; 60 per cent had suffered for a long time from obstinate constipation, 28 per cent had had diarrhea before admission, and 12 per cent had no recollection of being troubled with either. "None of the figures depending upon the memory of the patients must be taken as absolute truth, as the intelligence of many is of a very low order." Diarrhea, and even dysentery, are not uncommon in very advanced cases, especially those complicated with *Bilharzia* (= *Schistosoma*, which has not been reported as endemic in the United States), or ulceration in the rectum; and unless the patient is robust enough to support thymol, such cases are apt to end fatally.

In my own cases I found both constipation and diarrhea, but I am not in a position to state that either symptom was regular or characteristic for any given degree or stage of infection. In severe cases diarrhea was certainly more or less common.

Feces.—See page 68.

NERVOUS SYSTEM.

The nervous symptoms usually develop later than either the intestinal or the circulatory symptoms.

EYES.

See page 65.

EARS.

According to Sandwith (1894, p. 12), noises in the ear are present. None of my patients complained of this symptom.

MENTAL LASSITUDE, HEADACHE, DIZZINESS, AND NERVOUSNESS.

Not only does physical exertion result in exhaustion, but mental exertion has to be avoided. The children complain that they are unable to study and that any continued application to books results in

severe headache. This feature of the disease is fully confirmed by the testimony of both teachers and parents, who assert that children of this class are usually much more backward (and even stupid in their studies) than other children not showing the symptoms under discussion.

Dizziness is very commonly mentioned by the patients. This feeling, which they usually speak of as a "swimming in the head," is experienced especially upon rising suddenly from a chair or a bed.

Nervousness does not seem to be so commonly complained of as mental lassitude, headache, and dizziness. Still it is more or less frequently mentioned, more particularly by the girls and women.

Among girls from about 13 to 20 years of age it was quite noticeable that they were more timid and more emotional than were their healthier sisters.

According to Sandwith (1894, pp. 11-12), there is pain in the head, generally referred to the temples, while in the knees there is almost invariably present great weakness and some pain; occasionally there is in addition pain in the shoulders. Giddiness is another very general symptom, and it is this as much as anything else which compels the patients to give up work. The worst cases are those which are nearly always asleep, and can not be interested in anything when they are awake. On the whole, sleepiness is decidedly a symptom. Dense stupidity, associated sometimes with reiterated demands for a favor already granted, shows that the bloodless brain is affected in all advanced cases, and at least three times Sandwith (1894, p. 13) found a condition of weak-mindedness which would have warranted the patients being sent to the asylum.

PATELLAR REFLEX.

Absence of patellar reflex is reported in cases of general debility and muscular weakness. Sandwith (1894, p. 13) found this reflex unaltered in 35 per cent of the cases examined, completely absent in 48 per cent, decidedly diminished in 5 per cent, and a little exaggerated in 12 per cent, all of which were early cases.

GENITAL SYSTEM.

EXTERNAL GENITALIA; SEXUAL FUNCTION; MENSTRUATION; STERILITY.

In cases where infection has taken place in early childhood, the delayed development of the genital system is very marked. Patients of 16 to 22 years of age may not be better developed than healthy persons of 11 to 15 years. Menstruation may be very irregular, especially in summer. This same condition is insisted upon in many early writings on dirt-eating. Mothers frequently ascribe the condition of their daughters to the absence or irregularity of the menstruation as is mentioned also in early writings on dirt-eating.

Sandwith (1894, p. 13) found impotence to be a decided symptom in hookworm disease. Of 38 men especially examined on this point, 24 had completely and 5 had almost entirely lost their virile power, while of the remaining 9 men, 5 aged from 19 to 25 had their puberty considerably delayed.

TENDENCY TO ABORTION.

Among women affected with uncinariasis I found a marked tendency to abortion. Given a woman about 28 years old who had been married nine years—a not uncommon history is that she has had 3 to 5 children and 3 to 4 miscarriages, and she looks to be about 50 years old. Not being able to follow these cases through their entire medical history and the history of their husbands, I must leave the question open as to how many of these abortions are to be attributed to uncinariasis and how many are due to other causes. In the country districts I was thrown in with the anemic not with the healthy families, hence I have no good basis for comparison of these two classes for the particular localities visited. In some cases a history of venereal disease was suspected or admitted; in others, the abortion came on after pitching fodder; in some cases the patients had taken more or less quinine during their life, under the supposition that they had malaria; and in still other cases, my suspicions were aroused in other directions. The determination of the exact relation of uncinariasis to the miscarriages, which are certainly strikingly prevalent, must be left to those who can follow the cases for a longer period of time.

PREVALENCE OF UNCINARIASIS IN THE UNITED STATES.

In several earlier papers (1901, p. 524; 1902 a, p. 778; 1902 b, pp. 183, 212) I have advanced the view that uncinariasis must be more common in this country than is generally supposed. In my preliminary report on this trip (see above, p. 35), I said that: "There is in fact not the slightest room for doubt that uncinariasis is one of the most important and most common diseases of this part [South Carolina] of the South, especially on farms and plantations in sandy districts."

Harris (see above, p. 36) went even farther than this and claimed that uncinariasis is "the most common of the severe diseases of the South."

In considering the subject of the frequency and economic importance of the disease under discussion, I do not wish to seem to underestimate the prevalence of tuberculosis and of venereal diseases among the negroes or of malaria among the whites. Further, I recognize the fact that at the present moment an exact mathematical estimate can not be made. Speaking in general terms, however, the facts at my disposal at present seem to indicate that taking the Southern Atlantic

States as a whole, uncinariasis must be considered as one of the most common and widespread maladies; in frequency it belongs in the general class with malaria, tuberculosis, and gonorrhea.

In cities and in rural clay districts it is probably less common than any one of these three maladies, for such localities may present local foci of infection for the diseases in question, while the local foci of infection with uncinariasis are much more limited.

Among the negroes of the rural sand districts, uncinariasis seems to be much less common than either tuberculosis or gonorrhea. Its apparent rarity may, however, be deceptive (see p. 51).

Among the whites of the rural sand districts, uncinariasis is apparently the most common disease found. Nevertheless, in some sand districts, probably with a clay or other impervious subsoil favorable to the formation of marshes, malaria rivals uncinariasis for first place.

From these qualified statements it will be seen that I do not feel justified in adopting the view advanced by Harris, namely, that uncinariasis is "the most common of the severe diseases of the South."

In all probability, further study will show that in Mexico, Central America, and parts of South America, hookworm disease is more important and more common than in the United States.

Sandwith (1894, pp. 5-6), in discussing the frequency of this disease in Egypt, says:

"It is impossible to know what amount of the population [of Egypt] is affected, but the statistics of the recruiting commissioners for 1892 are worth quoting. Nearly every adult male peasant is liable for conscription, and the conscripts are immediately examined in their villages. In upper Egypt 5,988 men were called, and 200, or 3.3 per cent, were rejected for anæmia. In lower Egypt 661, or 6.2 per cent were rejected from this cause out of 7,420 men. Every province furnished anæmic rejections, but Menoufieh came highest on the list with 13.9 per cent, while I find from hospital statistics that no less than 15 villages in that province are infected. The recruiting medical officer, who is an Englishman, only rejects those who are obviously too anæmic to serve with the colors, accepting many who are already the hosts of the bloodsucking worm. Thus the medical reports for the Egyptian army show that in 1890 there were 114 admissions to the hospital for anæmia, in 1891, 107 admissions, and in 1892, 170 admissions. In 1891, 22 soldiers were invalided from the service for anæmia, and 65 in 1892, besides 1 death. The number of admissions for debility is equal to those for anæmia, and doubtless includes many cases of anchylostomiasis."

Dobson (1893, p. 63), examined 547 of the healthiest looking coolies from India and found hookworms in no less than 454 of them.

CLINICAL DIAGNOSIS OF HOOKWORM DISEASE.

As stated above, a man who is familiar with this disease should have no difficulty in recognizing severe cases, especially if he is in the area of infection. In light and medium cases, however, it is unsafe to make a diagnosis upon symptoms alone, unless such cases are associated

in the same family or neighborhood with severe cases. The best and most reliable method of diagnosis is by fecal examination, although in blood examination increased eosinophilia indicates the possibility of intestinal parasites.

First of all let us recall that uncinariasis is a possibility which should be considered in connection with all cases of anemia, especially among earthworkers, as in miners, brickmakers, canal diggers, farmers, etc., or in persons returning from the tropics, and among persons who have a history of residence on sandy soil. Three methods of fecal examination are open to us—the blotting-paper test and the microscopic and the gross examinations.

BLOTTING PAPER TEST WITH FECES.

For persons who are not in a position to make a microscopic examination, the blotting-paper test (referred to on p. 69), will be found very useful. To make the test, use only fresh feces. Place an ounce or more of the stool on a piece of white blotting paper (any absorbent white paper will answer the purpose); allow it to stand for twenty to sixty minutes; remove the feces and examine the color of the stain. In about four out of five cases of medium or severe uncinariasis, the stain is reddish brown and immediately reminds one of a blood stain. In making this test on anemic patients, piles should of course be excluded.

It developed in my work in the Virginia penitentiary, that this test is open to error in dealing with criminals. In order to avoid work, convicts, especially hard-labor contract convicts, occasionally produce a hemorrhage purposely by wounding the mucosa of the rectum by means of some sharp instrument.

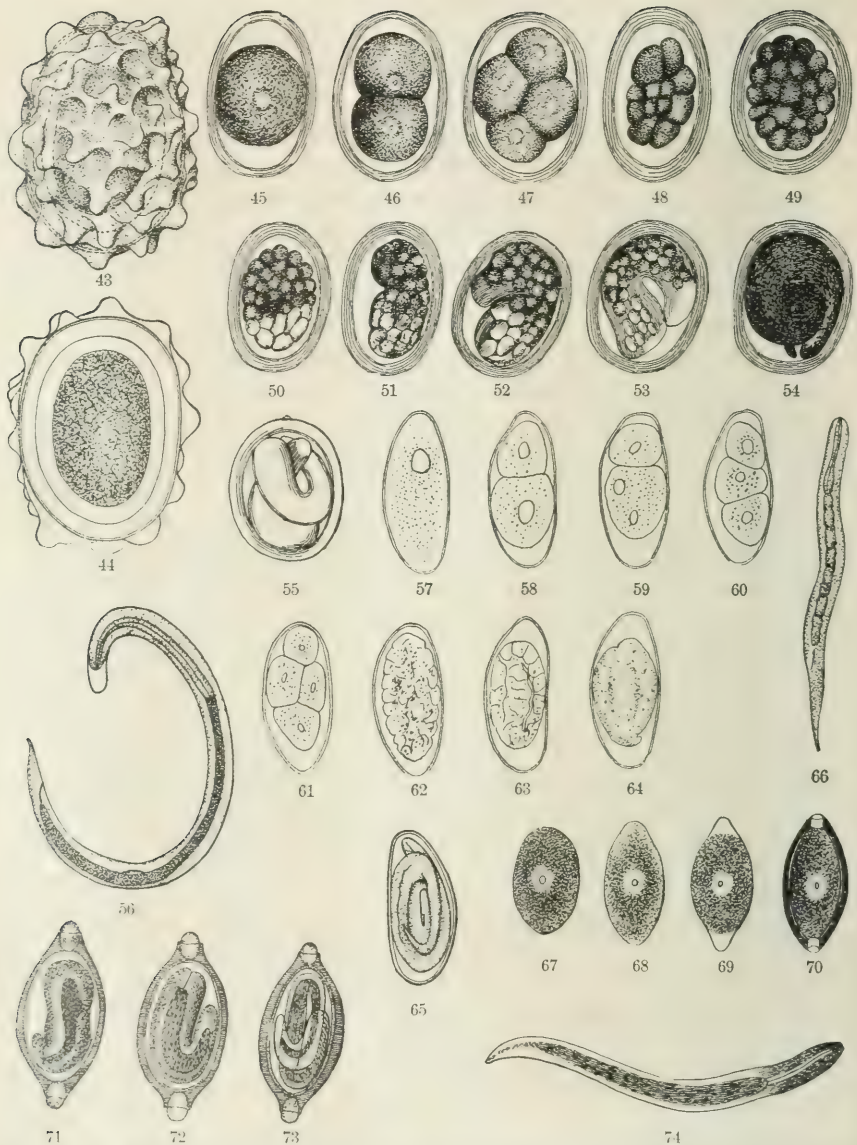


FIG. 43.—Egg of the common ascaris (*Ascaris lumbricoides*) of man, as found in feces. Seen with superficial focus. Greatly enlarged. (After Stiles, 1902b, p. 202, fig. 158.)
 FIG. 44.—The same, as seen with median focus. Greatly enlarged. (After Stiles, 1902b, p. 202, fig. 159.)
 FIGS. 45-54.—Embryology of the common ascaris (*Ascaris lumbricoides*) of man, showing the changes undergone by the egg after being discharged in the feces. (After Leuckart, 1867, p. 213, fig. 154.)
 FIG. 55.—Embryo of the common ascaris (*Ascaris lumbricoides*) of man, in the eggshell. (After Leuckart, 1867, p. 215, fig. 156.)
 FIG. 56.—Free embryo of the common ascaris (*Ascaris lumbricoides*) of man, casting its skin. (After Leuckart, 1867, p. 214, fig. 155.)
 FIGS. 57-64.—Embryology of the common pinworm (*Oxyuris vermicularis*) of man, showing the changes undergone by the egg while in the female worm. (After Leuckart, 1868, p. 322, fig. 191.)
 FIG. 65.—Embryo of the common pinworm (*Oxyuris vermicularis*) of man, in the eggshell, as found in fresh feces. (After Leuckart, 1868, p. 328, fig. 196.)
 FIG. 66.—Full-grown embryo of the common pinworm (*Oxyuris vermicularis*) of man, after it has escaped from the eggshell. (After Leuckart, 1868, p. 328, fig. 195.)
 FIGS. 67-70.—Egg of the common whipworm (*Trichuris trichiura*) of man, showing changes undergone while still in the female worm; fig. 70 is the stage found in fresh feces. (After Leuckart, 1868, p. 491, fig. 275.)
 FIGS. 71-73.—Later stages of development of an allied whipworm (*Trichuris affinis*) of sheep and cattle, showing changes after the egg escapes in the feces. (After Leuckart, 1868, p. 494, fig. 276.)
 FIG. 74.—Isolated embryo of *Trichuris affinis*. (After Leuckart, 1868, p. 495, fig. 277.)

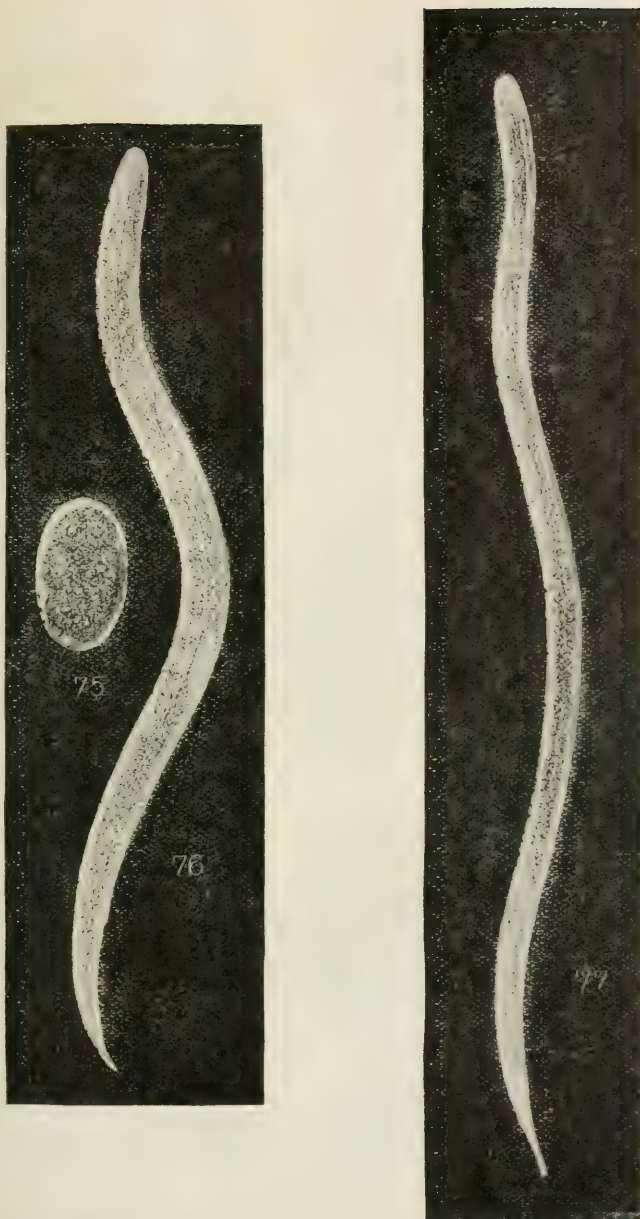


FIG. 75.—Egg of Cochin-China diarrhea worm (*Strongyloides stercoralis*) found in stools. (After Thayer, 1901, pl. 9, fig. A.)

FIG. 76.—Rhabditiform embryo of same, from the stools. (After Thayer, 1901, pl. 9, fig. B.)

FIG. 77.—Filariform larva of same derived, by direct transformation, from a rhabditiform embryo. (After Thayer, 1901, pl. 9, fig. C.)

Figures 75 to 77 were drawn from life, as seen under Leitz, objective 7—ocular 3.

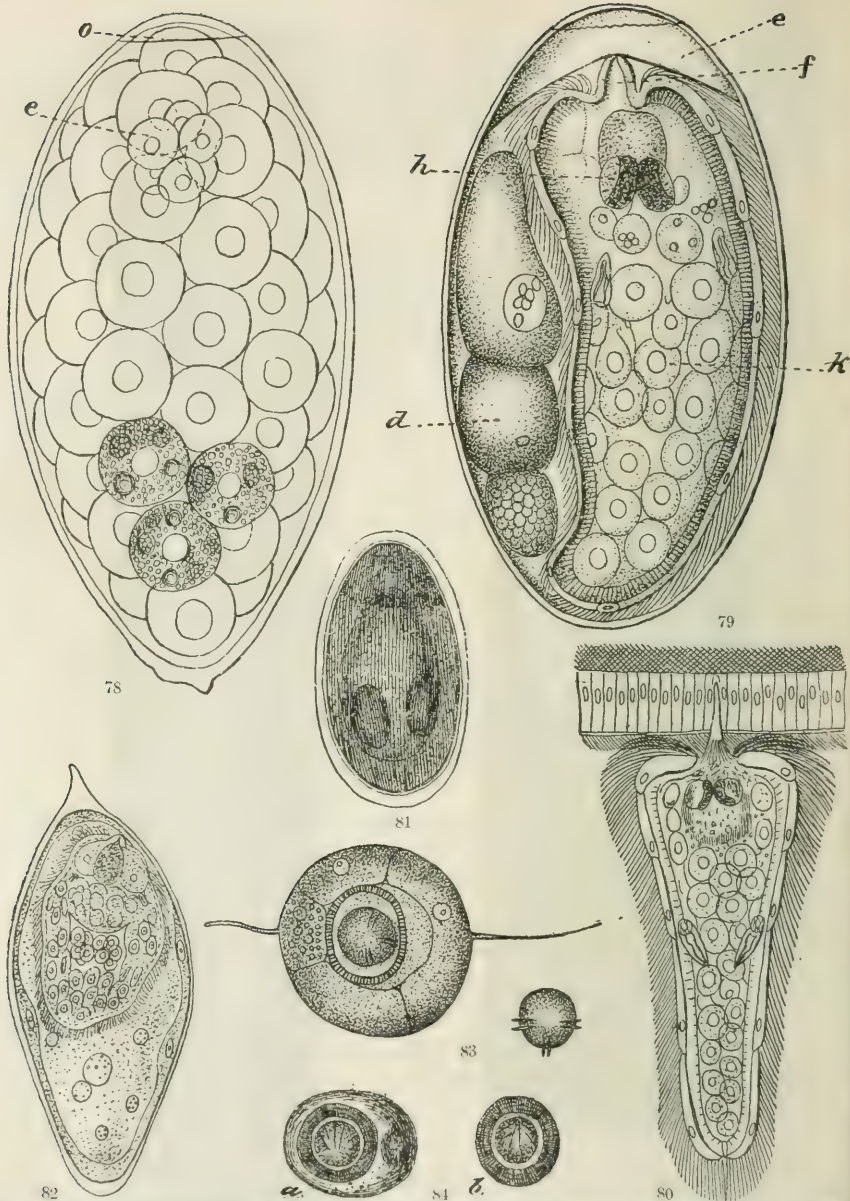


FIG. 78.—Egg of the common liver fluke (*Fasciola hepatica*) examined shortly after it was taken from the liver of a sheep; this is the same stage that is found in human feces; at one end is seen the lid or operculum, *o*; near it is the segmenting ovum; the rest of the space is occupied by yolk cells which serve as food; all are granular, but only three are thus drawn. X 680. (After Thomas, 1883, p. 281, fig. 1.)
 FIG. 79.—Egg of the common liver fluke containing a ciliated embryo (miracidium) ready to hatch out; *d*, remains of food; *e*, cushion of jelly-like substance; *f*, boring papilla; *h*, eye-spots; *k*, germinal cells. X 680. (After Thomas, 1883, p. 283, fig. 2.)
 FIG. 80.—Embryo of the common liver fluke (*Fasciola hepatica*) boring into a snail. X 370. (After Thomas, 1883, p. 285, fig. 4.)
 FIG. 81.—Egg of lancet fluke (*Dicrocoelium lanceolatum*) with contained embryo. X 700. (After Leuckart, 1889, p. 379, fig. 171.)
 FIG. 82.—Egg of human blood fluke (*Schistosoma haematobium*) with contained embryo, passed in the urine or in the feces. X 280. (After Looss, 1896, pl. 11, fig. 112.)
 FIG. 83.—Egg of beef-meat tapeworm (*Tenia saginata*) with thick eggshell (embryophore), containing the six-hooked embryo (oncosphere) enlarged. (After Leuckart.)
 FIG. 84.—Eggs of pork-meat tapeworm (*Tenia solium*); *a*, with primitive vitelline membrane; *b*, without primitive vitelline membrane, but with striated embryophore. X 450. (After Leuckart, 1880, p. 667, fig. 297.)

No special technique is necessary. Simply take a small amount of feces, preferably from near the surface, about the size of the head of a large pin; spread this out in a drop of water on an ordinary microscopic slide and cover the preparation with a cover slip. Examine under any moderately high power, as a Zeiss 8 mm., Zeiss C, or a Bausch & Lomb one-fourth inch. Look carefully, with not too strong illumination, for an elongate oval egg with thin shell, and with protoplasm either unsegmented or in the early stages of segmentation. The older the feces and the warmer the weather the more advanced will be the segmentation. In case of infection with *Uncinaria americana* the fully developed embryo may be found within the eggshell. Be cautious not to mistake for the egg of the *Uncinaria* the eggs of *Ascaris lumbricoides*, which have a thick gelatinous, often mammillated, covering and an unsegmented protoplasm (figs. 43-44), or the eggs (figs. 57-65, of *Oxyuris vermicularis*, with a thin asymmetrical shell (one side being almost straight) and containing an embryo, or the eggs of whipworms (*Trichuris trichiura*, more commonly known to physicians as *Trichocephalus dispar*), possessing a smooth, thick shell, apparently perforated at each pole, and an unsegmented protoplasm (fig. 70).

As a rule, in fecal examination I prefer to use the thick, large, 2 by 3 inch slide, such as is used in examining for trichinae, rather than the ordinary 1 by 3 thin "English slide." The larger slide is not only more steadily and more easily manipulated in case one is working without a mechanical stage, but it is much cleaner to handle.

In most cases of infection with intestinal worms the simple method just described will suffice for a positive diagnosis. Before giving a negative opinion, however, I invariably make ten preparations or follow a procedure which we may call "sedimenting the feces." Experience has shown me that in cases of negative diagnosis by the simple method positive diagnosis occasionally results if the feces are washed and "sedimented."

Method of washing and sedimenting feces.—Take one or two ounces of feces, fresh or dry, mix with water, and place in a large bottle, retort, jar, or any other receptacle; add enough water to make from a pint to two quarts, according to the amount of feces; shake or stir thoroughly and allow to settle; pour off the floating matter and the water down to near the sediment; repeat the washing and settling several times, or as long as any matter will float. The last time this is done use a bottle or graduate with a smaller diameter, and when the material is thoroughly settled examine the fine sediment. It will be

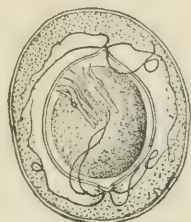


FIG. 85.—Egg of the dwarf tapeworm (*Hymenolepis nana*) of man. Greatly magnified. (After B. H. Ransom, unpublished.)

found that the eggs have settled more numerous in the fine sediment than in the coarse material.

In case an unusual amount of large coarse material is present in the feces, it is sometimes convenient to pour the entire mass through a sieve, rejecting the portion left in the sieve; or to wash the feces in a sieve, holding the latter under water. As a rule, however, the sieve is not very useful in fecal examinations.

The centrifuge does not appear to be of any special value in fecal examinations.

If facilities are not at hand for making a microscopic examination, about half an ounce of either perfectly fresh feces, or of rather dry feces, may be placed in a bottle, preferably with a large neck, properly packed in a mailing case, and sent to any professional pathologist or zoologist for examination.

GROSS EXAMINATION OF FECES.

If uncinariasis is suspected and it is not practicable either to make a microscopic examination or to delay matters until a specimen can be sent away for examination, still another method of diagnosis is possible. Give a small dose of thymol, followed by salts, and collect all of the stools passed. Wash the stools thoroughly several times in a bucket, and examine the sediment for worms about half an inch long, about as thick as a hairpin or hatpin, and with one end curved back to form a hook. If these are found, institute definite treatment.

TREATMENT OF HOOKWORM DISEASE.

ANTHELMINTHIC TREATMENT.

The two drugs most commonly used in uncinariasis are thymol and male fern. The day before treatment the patient is placed on a milk and soup diet for three days.

Thymol.—The directions usually given for thymol treatment are these: Two grams (31 grains) of thymol at 8 a. m.; 2 grams (31 grains) at 10 a. m.; castor oil or magnesia at 12 noon.

One week later the stools should be examined, and if eggs are still present, treatment should be repeated until the eggs disappear, but it is not best to give the thymol more than one day per week. Some cases of hookworm disease are quite obstinate and require a treatment extending over several weeks. It is, therefore, an unfortunate error to expel a few worms with one or two doses and then dismiss the patient as cured without having made further microscopic examination for eggs.

Sandwith (1894, p. 21) reports 42 men cured after a single dose; 58 after 2 doses; 43 after 3 doses; 25 after 4 doses; 9 after 5 doses; 4 after 6 doses; 2 after 7 doses, and 2 after 8 doses.

A number of writers, particularly Giles, Sandwith, and others, agree that small doses of thymol are valueless, but Sandwith is of the opinion that 4 grams in 24 hours are as efficacious as 6 grams, and the former dose is certainly less dangerous.

Worms may be found in the stools as early as eight hours after the first dose of thymol. In 50 cases Sandwith counted 1,301 worms in stools passed within eight hours after the first dose and 444 worms within the next sixteen hours. From his context, however, it is clear that brandy was given to these patients (see below), hence the thymol was dissolved more rapidly. Giles reports that he seldom found any worms until twelve hours after the first dose of thymol. "Occasionally patients vomited after swallowing thymol, but as a rule they retained it perfectly," and "they used to ask for an extra dose of it while convalescing."

Sandwith goes on to say that "large doses of thymol have a poisonous effect on the system, not unlike those produced by carbolic acid. The temperature is lowered one or even two degrees centigrade, and both pulse and respiration are slowed. The patient remains for a few hours collapsed, giddy, and faint, and has to be kept lying down, but at sunset he is quite well again and asking for food." He gives the following as a typical case:

"January 14, 1892.—6 a. m., temperature 37.5°, pulse 80, respiration 19; patient in his usual state and was given 2 grams of thymol. 7 a. m., temperature 37°, pulse 80, respiration 19; says he has slight nausea, giddiness, and colicky pains in the epigastrium. 8 a. m., 2 grams more of thymol given. 9 a. m., temperature 35.5°, pulse 70, respiration 17; great giddiness, can not stand or walk; very sleepy, and talks like a drunken or very sleepy man. 12 a. m., symptoms much the same; sweating while asleep. 2 p. m., temperature 37.5°, pulse 75, respiration 18; apparently quite well again. Says he does not mind the thymol, except that it makes him lose consciousness."

Some authors advise the use of alcohol with thymol, others warn against such use. Sandwith, in referring to this subject, says: "Warned by the death of at least one of my patients immediately after digesting the thymol, I have always administered to feeble men 25 grams of brandy with each 2 grams of thymol, with the happiest results."

Authors who warn against the use of alcoholics during treatment do so on the ground that thymol is soluble part for part in alcohol, hence will more quickly be absorbed by the system. With one of my assistants (see Stiles & Pfender, 1902a), in the Bureau of Animal Industry, I treated a number of dogs with thymol in various forms. We gave doses varying from 10 to 100 grains (0.648 to 6.48 grams) to dogs weighing from 8 to 35 pounds. In alcoholic solution, 30 grains (1.94 grams) caused convulsions in a dog weighing 15 pounds, and severe convulsions in one weighing 14 pounds; on the other hand, an 8-pound, old dog suffered no ill effects after 30 grains in alcohol, and a 35-pound

dog took 75 grains (4.86 grams) in alcohol without deleterious effect. In tablet form, without oil, a single dose of 100 grains (6.48 grams) killed a dog of 15 pounds in four days; a dose of 50 grains caused a 12-pound dog to attempt to vomit; a dose of 75 grains was without appreciable effect in a dog of 35 pounds; 30 grains were without effect on a dog of 8 pounds; daily doses of 20 grains each caused a slight diarrhea after six days in a dog of 15 pounds; the same dose caused a 17-pound dog to be quite sick on the sixteenth day. In tablet form, with castor oil, 30 grains caused a 12-pound dog to attempt to vomit, while doses of 10 and 20 grains were negative on dogs weighing 12 to 15 pounds. In powdered form, without oil, 20 grains caused a 12-pound dog to attempt to vomit, while doses of 10 and 20 grains respectively were negative in dogs of 12 and 15 pounds; 40 grains caused no ill effects in a dog of 8 pounds, and a dose of 80 grains was without effect on a dog of 35 pounds. In powdered form, with castor oil, 20 grains caused slight convulsions in a dog weighing 15 pounds, but doses of 10 and 20 grains were negative on dogs of the same weight. Blue foxes to which we gave 3 grains in alcohol became quite sick. Theobald states that a dose of 3 grains has produced partial prostration in a bull-terrier, but he does not give the weight of the dog.

According to Sandwith, the contra-indications for thymol are "excessive debility, very low temperature, age above 60, and advanced diseases of the heart or any other organ. Boys take it very well in half quantities."

Sandwith states (1894, p. 17), that of 8 fatal cases treated with thymol 2 died, he thinks, in consequence of the thymol, eleven and forty-eight hours, respectively, after taking the dose; both of these men had previously had thymol without bad effect, but they were both in a miserable state of exhaustion and debility. He does not think that thymol accelerated the deaths of any of the remaining 6 cases, which occurred five, six, nine, thirteen, fifteen, and nineteen days, respectively, after the last dose of thymol. Three of these cases were over 65 years of age.

While my experience with thymol in man is very limited, I must confess that from my experiments upon animals, I am afraid of the use of alcoholics *per os* during treatment, and in the case of weak patients I should be more inclined to use a stimulant hypodermically than run the risk of dissolving the thymol too rapidly or in too great quantity at one time. Furthermore, it is at least doubtful whether our American hookworm will be so difficult to expel as is the Old World species, because of the absence of the ventral hooks (cf. figs. 5 and 10) in *Uncinaria americana*.

In the case of "excessive debility" and other conditions which Sandwith designates as contra-indications for thymol, it is not clear what drug Sandwith would use, for he states (1894, p. 20) that "for

the last three years I have looked upon it as a waste of time to administer any other anthelmintic than thymol for this parasite" [*Agchylostoma duodenale*]. Certainly persons in the conditions described should not be allowed to go untreated, and despite the view advanced by some authors, smaller doses of thymol, repeated one day per week and extending over several weeks, may be expected to yield some results.

Male fern.—Several European authors advise the use of large doses of extract of male fern in treating hookworm disease. Eichhorst's (1901, p. 314) recent "Practice" places the dose at 10 grams (2.5 fluid drams) to 20 grams (5 fluid drams). It has been pointed out by Lépine (1891a, 1891b) and others that such large doses of this drug are likely to be followed by serious toxic symptoms and even by death. Lépine summarizes the conditions as (1) symptoms of gastrointestinal irritation characterized by the redness and the hemorrhages; (2) nervous symptoms (convulsions and paralysis); (3) albuminuria, and (4) glycosuria, and he warns not to give over 8 grams of the extract as a maximum dose. Hare gives the dosage of the extract as 4 to 8 grams (about 1 to 2 fluid drams). Male fern should be followed in three to four hours by a calomel purge, aided by a saline, but not by castor or other oils, as the latter increase the danger of absorption, hence of poisoning.

Calomel.—While thymol is at present considered the most reliable remedy in hookworm disease, indications are not lacking (see p. 76) that considerable good may be accomplished in the American form of the disease by the use of calomel. This drug will not, however, be followed by such prompt and satisfactory results as will thymol.

GENERAL TREATMENT.

The administration of thymol has for its object the expulsion of the parasite, hence the removal of the cause of the disease. This should be supplemented by efforts to build up the depleted system by means of good nourishing food, iron, etc. It is well to give the iron daily, except on the days that thymol is taken. Sandwith (1894, p. 25) claims that the blood was most benefited by a daily supply of 1.5 grams (23 grains) of the sulphate of iron in water in three equal doses.

PROGNOSIS.

Among physicians I found the view rather prevalent that the prognosis was poor for children who presented severe cases of the disease. This view is probably due to the fact that the cause of the trouble was not understood, hence treatment was not directed to removing the cause.

The proposition now before us is, first, to remove the intestinal parasites, and second, to build up the patients.

To accomplish the first desideratum may require some patience, but efforts will eventually be successful. The second point may also be carried out, unless, of course, the patient is too far gone at the time of treatment to recover from the effects of the disease.

In not all cases can it be expected that a dwarfed, emaciated, and stupid child can be immediately placed upon the same physical and mental basis as his brothers, but even such cases can be greatly improved.

LETHALITY OF HOOKWORM DISEASE.

I know of no extensive and exact statistics regarding the lethality of uncinariasis, and traveling as rapidly as I did, it was impossible to establish any definite facts from personal observation, since it was the exception that I saw any case more than once. Furthermore, owing to the fact that many light cases will escape attention, any lethality percentages published will probably be above the actual figures.

I doubt whether sufficient data are at hand to justify even approximate statements regarding the lethality of hookworm disease. That numerous cases, not properly treated, terminate fatally can not be doubted. Still, it is remarkable how low a person may be with hookworm disease and still live.

Among physicians I met with the most contradictory ideas on this subject. Several excellent observers maintained that all severe cases which reached an edematous condition were invariably fatal; equally keen observers doubted whether this disease was frequently the actual cause of death; the view was quite general that patients suffering from medium or severe attacks of this malady very seldom lived through even medium or light attacks of such diseases as typhoid fever, or pneumonia, and that severe attacks of malaria were frequently fatal; also that they were very uncertain patients in confinement.

In my own observations, several points seemed quite significant. In the first place, the large number of cases of long standing found in so many families did not indicate a high lethality. Further, several adults were seen who had formerly unquestionably presented severe infections, but who are now in a fairly good state of health. In one family with 9 children living, most of whom clearly presented light, medium, or severe infections, there was a history of death of 9 other children, but satisfactory answers as to the cause of these deaths were not obtained. That some of the children had died of uncinariasis is very probable. On the other hand, families were seen with 8 to 10 children, all or nearly all in an anemic condition, some with clear medium to severe cases of uncinariasis, yet without history of any fatal case in the family. I have heard of localities in Central America (but have not investigated them personally) where it is said that a dis-

ease, which from its description I believe to be uncinariasis, probably due to *Uncinaria americana*, causes an immense mortality among the children.

Taken all in all, the data obtained did not convince me that uncinariasis, *per se*, is so fatal a disease in man as is generally supposed. On the other hand, I obtained the impression that while very severe cases are not infrequently fatal, the general effects of the malady upon the system are of greater and more far-reaching importance than the lethality of the infection itself. In other words, if uncinariasis were eliminated, the lethality of other diseases, such as pneumonia, typhoid fever, malaria, and also of child birth, would be decreased, and in the sand and mixed sand and clay areas this decrease would not be an insignificant factor.

One physician stated to me that he was confident that he had lost several hundred patients from uncinariasis within the past forty years.

Sandwith (1894, pp. 16-17) states that of the patients nominally under his care, 89.5 per cent were cured or greatly improved, 2.5 per cent were unrelieved, and 8 per cent died.

"Most of the fatal cases had loud anemic murmurs, marked subnormal temperature, slight general edema, albuminuria, and great mental weakness.

"The actual cause of death was exhaustion, from utter absence of rallying power. It is difficult to believe that the pathological effects are induced only by hemorrhage from the daily suction of scores or even hundreds of worms. In addition to the loss of blood, we have general thickening and degeneration of the duodenum and jejunum, and consequent interference with normal digestion; then nonassimilation, and eventually a process of slow starvation. It is also worthy of consideration that there may be in prolonged cases some self-poisoning from the great number of bites in the walls of the intestines containing ill-digested and perhaps decomposing food."

POST-MORTEM APPEARANCES.

I did not have occasion to make any autopsies during the trip; hence I am unable to present any original observations in this line. For careful accounts of single cases of autopsies, the reader is referred in American literature to Strong (1901), Yates (1901), Claytor (1902a), and Capps (1903a).

Sandwith's (1894, pp. 17-20) summary of 26 autopsies is not accessible to many American physicians; hence it is quoted here in full.

"Some of the earlier autopsies were made by myself, the later ones by Dr. Kaufmann. The muscles were in one case described as of normal color, but in all others they were very pale. There was usually a great absence of subcutaneous fat. The lungs were very pale and edematous in all cases, and all the organs were extremely bloodless.

"In one case there was noted edema of glottis. The heart was found to be hypertrophied ten times [in 10 cases], and was very small twice, generally pale brown in color, and on three occasions there were marked changes in the mitral valve. The most common abnormality in the liver was a brownish-yellow fatty appearance.

In one case there were several abscesses and the liver weighed 3,700 grams, and in one patient there was well-marked jaundice.

"The spleen was enlarged in one-third of the post-mortems. The kidneys invariably showed some change, though this was often much more marked in one kidney than in the other. They were very pale in 24 patients, 3 of whom had several small cysts. Of the remaining 2 patients one had granular kidneys and the other had cysts, but the kidneys were of normal color.

"The brain was always exceptionally white, and in one case there was recent apoplexy.

"The small intestines showed, of course, the most important changes. As a rule, there were many hemorrhages and bites in the jejunum and ileum, but in one of the cases where the bites were carefully counted there were only 6 in the jejunum and ileum, and no worms were found. In another case, however, there were 575 bites in the small intestine, besides 250 anchylostoma. In yet another there were 100 bites, the farthest of which was 4.5 meters from the pylorus. In only two cases was there much liquid blood in the intestine.

"I have not observed the constant changes in the mucous membrane of the stomach described by Giles. The great variability in the number of anchylostoma found at the autopsies is interesting. In 7 cases, all treated by thymol during life, no worms could be found. In an eighth case, also treated by thymol, but insufficiently, there were 10 worms. The remaining 18 cases had not had the advantage of thymol. Six of them, nevertheless, were found to have less than 10 worms, and in two of these corpses only 1 worm was found in each jejunum. Three other cases numbered 20, 40, and 50 worms, but the remaining 9 had numbers varying from 170 to 381, terminating with the maximum record of 863. On that occasion the autopsy was made seven hours after death, and the worms were scattered from a point 1 inch beyond the pylorus for the length of 3 meters; 217 of the 863 were attached still to the intestine and were surrounded by much bloody mucus, while 646 were lying free in the intestine; 16 of the latter were still alive, and one couple were in copulation.

"Next the position of the worms deserves notice. It was quite the exception to find any parasites in the duodenum. Can it be that when the duodenum becomes thickened and riddled, as it were, with the ravages of former generations, the anchylostomum fastens by preference on to the jejunum? Some such cause as this suggestion of gradually shifting the pasture is required to explain the interesting fact that it is not the most advanced cases of anemia which will always yield the largest quantity of worms. In such cases the parasite must not only have to burrow extra deep, but the blood when reached is, of course, deficient in quantity. Or is it that the half-starved worms are dislodged by repeated attacks of diarrhea? The furthest feeding ground that I have seen was 6.30 meters from the pylorus, where there was a worm firmly attached." But, as a rule, the attached worms are all within 2 meters of the pylorus, and have their heads and sometimes half their bodies buried in the mucous membrane. It is often impossible to dislodge them by a strong stream of water, and they must then be pulled out by forceps.

"I examined about 50 cases to see the proportion of male to female worms, and found it 56 to 44 per cent. This is not in accordance with some of the authorities, who say that males are always more rare than females, and that males are less influenced than females by the action of expellent drugs."

"Dubini has only once seen the worm in the ileum. The nearest feeding ground seen by me was 24 centimeters from the pylorus. In that case there were 100 worms attached and 281 detached, besides oxyurides."

PREVENTION OF HOOKWORM DISEASE.

In the prevention of diseases caused by animal parasites, we may, of course, attempt to attack the infectious agent in any stage of its life history. In connection with uncinariasis, three periods in particular come into consideration, namely: (1) The adult worm in the intestine; (2) the egg in the feces, and (3) the infecting ("encysted") stage of the larva.

(1) ADULT WORM IN THE INTESTINE; TREATMENT.

The destruction of the adult worm in the intestine not only relieves the patient of an important and (when present in large numbers) serious or even dangerous parasite, but it is also an important factor in preventing the spread of the disease to other people. Accordingly, treatment should be instituted even if the eggs found in the feces are so few in number as to indicate only a light infection.

Not infrequently the opinion is expressed that the infection with parasites found in a given patient is so light that treatment is hardly necessary. Such a view, however, is often very shortsighted, for it is not infrequently light infections occurring at unfavorable seasons and under unfavorable conditions that furnish the material for heavy infections at more favorable times. No *Uncinaria* infection in man is too light to be worthy of treatment, for each adult female may lay eggs; hence the destruction of these females means the decrease of scores of free infectious larvæ.

Not all cases of the malady can be recognized without the microscope; hence many people will unconsciously spread the disease-producing agent. Furthermore, many cases which might be recognized by symptoms will not come under medical treatment, so that they, too, will spread the infectious material. It is clear, therefore, that for satisfactory results in prevention we must adopt some method in addition to the treatment.

(2) EGGS IN THE FECES; CONTROL AND DESTRUCTION.

It is in the feces that we find the potentially infectious material in the most concentrated form. After the eggs develop into embryos the latter may leave the fecal matter and be distributed in the sand or in the water. Accordingly, it is much easier to control or destroy a given amount of infectious matter while it is concentrated in the feces than it is later when it is spread over a larger area. Here, in fact, we have the key to the prevention of uncinariasis. Proper disposal of the fecal discharges will make the spread of uncinariasis impossible. As such proper disposal I will suggest: Properly built privies when sewerage is lacking; use of such outhouses after construction; cleaning the same at regular intervals, and burial, burning, disinfection, or drying of the feces.

(3) THE INFECTING ("ENCYSTED") STAGE OF THE LARVA.

Disinfection of premises.—A chemical disinfection of premises to kill the free stages of eggs, embryos, and larvæ of the parasite would

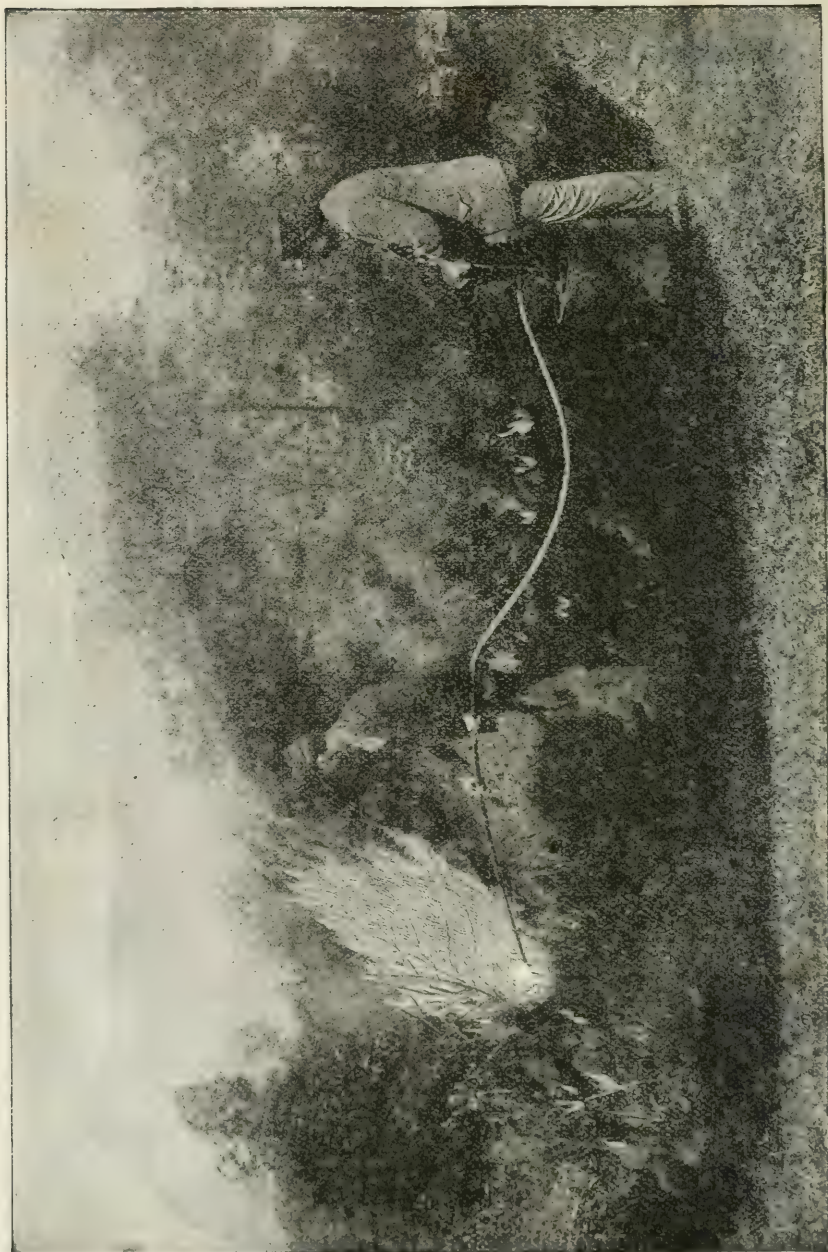


FIG. 86.—Spraying with burning oil, to kill superficial infection on premises where chemical disinfectants can not be used. (After Forbush & Fernald, 1896.)

hardly be practicable, but heat, dryness, and cold all result in killing these organisms.

About twenty-four to forty-eight hours of freezing temperature kills the free infection, hence after any cold weather of this kind in winter it may be assumed that the premises are disinfected.

After any especially dry weather, most if not all the free infection (except such as exists in places not affected by the dryness) is killed, so that exposed portions of premises may be assumed to be practically disinfected.

Spraying with burning oil (fig. 86), as practiced by the Massachusetts Gypsy Moth Commission, will effectually disinfect any area. If a spray nozzle or "cyclone burner" is not at hand, the ground around the house could be strewn with straw or brush and set afire (due precaution being taken not to burn the house), thus thoroughly disinfecting the premises. (See Stiles, 1902 d.)

Drinking water.—To tell the average farm hand or miner that he should always "boil or filter" the water before drinking it is, academically, a step toward preventing infection with uncinariasis. Practically, however, it is a step toward throwing away whatever influence we may happen to have with him. Theoretically, we should teach this simple hygienic precaution to all families, both in the city and in the country. Practically, we are in many cases weakening our position by insisting too generally upon this point.

While, therefore, we may warn people to boil or filter their drinking water in order to prevent the introduction of the infecting agent of uncinariasis or of other diseases, provided we see any chance of their following the advice (in regard to which we ourselves, except in times of epidemics, are very inconsistent), we will, I believe, usually weaken our influence with the poorer classes in mentioning a precaution which the average farm hand naturally looks on as absurd. It is much more important to urge him to locate his privy some distance from the well. That is a proposition he can appreciate; the necessity for boiling or filtering drinking water is usually beyond his mental horizon.

Clean hands.—An important point in connection with preventing the ingestion of the infectious agent of uncinariasis is that the hands and finger nails should be kept clean. I am inclined, however, to take an ultrapractical view of cleanliness versus dirt in connection with country houses, and to first see that the inevitable dirt shall be clean. This can be accomplished if we can succeed in having properly constructed latrines, built at proper distance from the wells and houses, if the children be taught to use them, and if the parents be taught the necessity for cleaning them.

These, in my opinion, are the first steps to be taken, and far outweigh all such considerations as boiling and filtering drinking water or keeping the hands clean.

Wearing shoes.—Wearing shoes during wet weather and washing the feet frequently will prevent the cutaneous infection and will protect to

a great extent against ground itch. It can hardly be expected, however, that the poorer children in country districts will adopt this precaution to any extent.

COMMON INTERPRETATION OF HOOKWORM DISEASE.

Upon several former occasions I have referred to "cases of anemia of obscure origin" as possibly due to uncinariasis. In a recent paper (Stiles, 1902b, pp. 207-208) I referred to "dirt-eating" as being possibly connected with uncinariasis; it was also intimated (1902b, p. 215), upon authority of Dr. Kirby-Smith, that in Mississippi uncinariasis is confused with malaria; Harris (1902c) also points out that much of the anemia attributed to malaria and dirt-eating is probably due to hookworm disease.

At present I am able to make more specific statements than formerly. The condition which should be attributed to light infections of uncinariasis is usually interpreted as due to malaria or diarrhea; medium cases are usually interpreted as an anemia due to malaria combined with "improper diet" or "insufficient nourishment;" severe cases are usually attributed to "malarial cachexia," "dirt-eating," "resin-chewing," "heart disease," "dropsy," "general debility," "pernicious anemia," and "lack of proper nourishment." Such at least are the most common diagnoses which have been made by the attending physicians in the cases which I have interpreted as light, medium, or severe infections with *Uncinaria americana*.

ECONOMIC IMPORTANCE OF HOOKWORM DISEASE.

Malaria is admittedly one of the most important diseases when viewed from an economic standpoint. In general, uncinariasis is, in the South, fully as important as malaria, and in some respects it is of even greater importance.

Take a given farming area in the sand district with an infection of uncinariasis, and assume that 100 farm hands are employed. It is not an exaggeration to say that these 100 people are not doing the work of 80 or 90 average hands. Thus there is a distinct loss of 10 to 20 per cent in the wages and a corresponding loss in the crop returns. In some places I should estimate the loss at even a higher percentage, say an average of 25 per cent, while in several families which I have examined I should say that uncinariasis is reducing the laboring capacity, hence the productiveness, of the family to as low as 30 to 40 per cent, thus entailing a loss of 60 to 70 per cent.

Nor are the losses in wages and in the laboring capacity, and the decrease of productiveness of the family, hence of the farm, and finally of the county and State, the only economic considerations involved. Cases are not unknown where families have sold, moved, or destroyed their homes, or were about to do so, because of the existence of this disease and because of the belief that it might be due to the locality in which they lived.

Again, it is almost a common experience to be told by the father of a family that he spends for medicine all he earns, in the hope of ridding his children of this malady. Add to this the physicians' bills, the loss by death and funeral expenses, etc., and it is seen that this infection is keeping more than one family in absolute poverty.

Nor should we forget that uncinariasis has its important bearing upon the mental as well as upon the physical and financial development of the poorer white people. As already stated, children infected with this malady are often underdeveloped mentally; frequently they have a reputation in the schools, in the neighborhood, and in their own family, of being "stupid," or "dull," or "backward" in their studies, etc. It has already been mentioned that children suffering with this disease are frequently kept home from school because of their tendency to become edematous when they sit still for any length of time. When we now recall that these conditions coincide especially with the educational period, it should not seem strange that uncinariasis has a marked influence upon the general intellectual condition of the districts in which it occurs.

Considering the subject in the light of all I saw on the trip, and taking what I believe to be a conservative view of the subject, I find it exceedingly difficult to escape the conclusion that in uncinariasis, caused by *Uncinaria americana*, we have a pathologic basis as one of the most important factors in the inferior mental, physical, and financial condition of the poorer classes of the white population of the rural sand and piney wood districts which I visited. This sounds like an extreme statement, but it is based upon extreme facts.

By this position I do not intend to assert that uncinariasis is the only factor which comes into consideration. The warm climate and the monotonous diet, and probably also the excessive use of tobacco in some cases, are not without influence. Still, with uncinariasis as it exists to-day, these people are suffering from a handicap in life which practically removes them from a fair chance in competition. If the uncinariasis is removed they will be placed in a more favorable condition both subjectively and objectively. With the present prevalence of uncinariasis their lack of ambition is perfectly natural; remove the disease and they can develop ambition.

On the other hand, if we were to select the strongest people in the country and place them in the conditions under which these patients are now living it would be only a generation or two before even a race of athletes would be in the same condition as the persons under discussion.

The conditions described are familiar to persons who have visited the rural sand districts. But they have existed for so many years that many of us to-day look upon them as natural, hence they do not attract the consideration to which they are entitled.

GEOGRAPHIC DISTRIBUTION AND ABSTRACTS OF CASES FOUND IN THE UNITED STATES.

In a former paper (Stiles, 1902b, pp. 206-217) I gave abstracts of all the cases of uncinariasis known to me at that time for the United States. The disease is now proved to be so common in certain portions of the country that it is hardly necessary to keep a full record of every case found, but on account of the medico-historical interest associated with the subject, and also in order to complete the literature and details of geographic distribution, there are here added abstracts and notices of various cases which have come to my knowledge since the above-mentioned paper was completed.

NEW ENGLAND STATES.

NEW HAMPSHIRE.

No positively diagnosed cases of hookworm disease seem to be recorded for this State.

Center Eppingham, 1876 ? 1 case, ? death.

GOULD (1876, pp. 417, 418) refers to a case of pica or dirt-eating which sounds suspiciously like uncinariasis.

MIDDLE STATES.

NEW YORK.

Rochester, 1868 ? 1 case, ? death.

ELY (1868, pp. 101, 102) describes a case of chalk-eating which may possibly have been due to uncinariasis, though this is by no means certain.

Buffalo, 1896 5 cases, 0 death.

MEHLAU'S (1897) cases. See STILES (1902b, p. 209). Doubts have arisen in the minds of some physicians as to whether these were actually cases of uncinariasis.

Glen Island, 1900 4 cases, 0 death.

ASHFORD'S cases from Porto Rico. Probably due to *Uncinaria americana*; reported in STILES (1902b, p. 210).

Stapleton 1 case, 0 death.

BAILHACHE'S, and GREENE'S (1901) case. Place of infection uncertain. See STILES (1902b, p. 215).

Albany, 1900 1 case, 0 death.

WARD (1902, pp. 23-26): American, physician, 32 years old. Had served in U. S. Army in the Philippines. Albany hospital, Feb. 6, 1902. Report on feces by Dr. GEORGE BLUMER, confirmed by Dr. W. S. THAYER.

? Albany, 1900 1 case, 0 death.

NEUMAN and BLUMER. Details of case not known to me.

PENNSYLVANIA.

It is by no means impossible that uncinariasis will be found among the miners of Pennsylvania. As so many of these men are immigrants from Europe, the Old World species, *Agchylostoma duodenale* may be expected.

Philadelphia, 1900-1901 3 cases, 0 death.

BOSTON'S cases reported by ALLYN and BEHREND (1901). See STILES (1902b, p. 211). Probably due to *Uncinaria americana*.

Philadelphia, 1901 1 case, 0 death.

ALLYN and BEHREND'S (1902) case, imported from Italy, hence due to *Agchylostoma duodenale*.

MARYLAND.

Baltimore, 1900 2 cases, 0 death.

HEMMETER'S (1902) cases; probably infected in Porto Rico and due to *Uncinaria americana*. See STILES (1902b, p. 210).

Baltimore, 1901 1 case, 1 death.

HALL'S (1901) case; imported, possibly from Vera Cruz. Due to *Agchylostoma duodenale*. See STILES (1902b, pp. 213-215).

Baltimore, 1902 1 case, 0 death.

OSLER'S case [unpublished]. In Johns Hopkins Hospital. Patient came from North Carolina. Parasites determined by Boggs as *Uncinaria americana*, confirmed by Stiles.

DISTRICT OF COLUMBIA.

Washington, 1901 [1 case, 1 death.]

CLAYTOR'S (1901a, 1902a) case, from Westmoreland County, Va., due to *Uncinaria americana*. See STILES (1902b, pp. 211-212).

Washington, 1902 1 case, 0 death.

HERRICK (1902, p. 101): Male, 37 years old, lived in Germany until 1897. Sent to Philippine Islands September, 1899. "Present illness began in July, 1900, with an attack of diarrhea. He had from 10 to 15 movements daily for three months, with a moderate amount of tenesmus. Mucus and blood appeared in the stools after the first month, giving them a dark tarry appearance. He lost weight and strength rapidly during this time and gradually became short of breath on slightest exertion. This was followed by a period of improvement, the stools becoming less frequent; but in January, 1901, he became worse and was sent to the hospital at Iloilo. Since then he has been confined to hospitals, on account of weakness and dyspnea. In September, 1901, the diarrhea ceased, and although he has gained a little weight he has been steadily growing weaker. At no time had he been subject to hemorrhages other than stated.

"Physical examination shows an apparently well-nourished man with a peculiar lemon-yellow pallor; conjunctivas and mucous membranes are pale; slight edema of the ankles is present. He has marked dyspnea on the slightest exertion. The lungs are negative; the heart is enlarged; the point of maximum impulse is in the fifth intercostal space in the nipple line. A soft blowing systolic murmur is audible at the apex and in the pulmonic area. Liver dullness extends from the sixth intercostal space in the nipple line to 1 cm. below the costal margin. The edge is palpable. The spleen is enlarged and the edge is palpable at the costal margin. The urine is negative.

"The blood is very pale and watery; a moderate poikilocytosis is present: there are no nucleated red corpuscles and no malaria organisms present. The blood count shows: Red corpuscles, 1,120,000; hemoglobin, 18 per cent; leucocytes, about 4,000; polymorphonuclear, 52 per cent; eosinophiles, 26.8 per cent; small mononuclear, 14 per cent; large mononuclear, 4.4 per cent; transitional, 2.8 per cent.

"One month later, the patient meantime having been taking arsenic and iron, the blood count was as follows: Red corpuscles, 1,450,000; hemoglobin, 22 per cent; leucocytes, 2,000; polymorphonuclear, 61 per cent; eosinophile, 18.2 per cent; small mononuclear, 16.4 per cent; large mononuclear, 3.2 per cent; transitional, 1.2 per cent; no nucleated red cells.

"There had been practically no change in the patient's condition. The liver and spleen were as in the former note, and the dyspnea was marked. Numerous typical ova of the *Uncinaria* were present in the stools, but no adult forms were seen. After the usual thymol treatment about 60 adult worms were found. They resembled in all respects *Uncinaria duodenalis*, and were identified by Dr. Stiles as the Old World hookworm. The ova present were in the progress of segmentation, 4 to 12 cells being visible. None were seen containing an embryo, as frequently occurs in the form *Uncinaria americana*, described by Dr. Stiles.

"Blood examinations, ten and twenty days after the thymol treatment was begun, showed the following counts:

	May 28, 1902.	June 7, 1902.
Red corpuscles.....	number.. 2,300,000	3,100,000
Hemoglobin.....	per cent. 23	27
Leucocytes.....	number.. 2,500	3,000
Polymorphonuclear.....	per cent. 54	62
Eosinophile.....	do..... 21	14
Small mononuclear.....	do..... 17	17
Large mononuclear.....	do..... 6	6
Transitional.....	do..... 2	1

"The general condition is also improving rapidly, although the parasites are not entirely eliminated, as an ovum is still occasionally found in the stools."

Anacostia (Government Hospital for the Insane), 1902 16 cases, 0 death.

Cases found on microscopic examination by Stiles, Garrison, Ransom, and Stevenson, of United States Public Health and Marine-Hospital Service. Probably most if not all of these were infected in other localities. (See p. 37.)

VIRGINIA.

Essex County, ? date..... ? cases, ? deaths.

Passed Asst. Surgeon JOHN F. ANDERSON has stated to me that there exists in Essex County a condition of "bloat" and anemia which is usually attributed to dirt-eating, and which corresponds in general to the conditions described in this paper.

Richmond, 1852..... ? 1 case, 0 death.

POLLARD (1852, p. 185) reports a case of dirt-eating. Its connection with uncinariasis is possible, but not clear.

Richmond, 1898..... 1 or 2 cases, 0 death.

GRAY's (1901) case. See STILES (1902b, p. 209).

Westmoreland County, 1901..... 1 case, 1 death.

CLAYTOR's case. See District of Columbia.

Westmoreland County, ? date..... 2 cases, 0 death.

Referred to by STUART in STILES (1901, p. 525, and 1902b, p. 212).

NORTH CAROLINA.

Judging from the size of the eggs, all the cases I found in North Carolina were due to *Uncinaria americana*.

Roanoke River Valley, prior to 1808 ? cases, ? deaths.

PITT (1808) states that malacia or dirt-eating "prevails mostly among the poorer white people and negroes, and originates in my opinion from a deficiency of nourishment." He refers also to the slowly healing ulcers on the legs, and to the "tallow complexion." His general description points quite distinctly to uncinariasis.

Person County, 1832 ? cases, ? deaths.

JORDAN (1832, pp. 18-30) gives a discussion of dirt-eating which quite positively refers, at least in part, to uncinariasis.

Durgy, Person County, 1902 2 cases, 0 death.

STILES (1903b, p. 38).

Cumnock Coal Mines, Chatham County, 1902 1 case, 0 death.

STILES (1903b, p. 38).

Gaston County, about 1880 ? cases, ? deaths.

The following interesting letter has been received from Dr. Barringer, and indicates the presence of uncinariasis in Gaston County:

"DEAR SIR: I have just seen in the Marine-Hospital Service Public Health Reports your letter of October 22, from Kershaw, S. C. I was for many years located in the district in which you have been working, and your letter has thrown an immense amount of retrospective light on what I saw there. My work was done in the early eighties, and yet I still remember many cases of pernicious anemia, which was accompanied in some cases by dropsical effusions and diarrhea, a combination I could never make out, and yet this must have been uncinariasis.

"Whole sections of the illicit distillers of Kings Mountain, in Gaston County, N. C., were affected, and the dirt-eating whites of this section seemed to have a malady different from those of the better class in the neighborhood. I tried a tannic acid preparation, which seemed to do more good than anything else, and I wish now I had tried Areca nut. By the bye, I also recall that my pointer dogs in this section seemed to be afflicted in the same way. During my stay in Gaston County, from 1878 to 1881, I lost two dogs, who used to follow me around to these houses, from an unknown disorder.

* * * * *

"I remain, yours, very respectfully,

"P. B. BARRINGER, *Chairman*.

"Dr. CH. WARDELL STILES,

"*Cure Marine-Hospital Service, Washington, D. C.*"

SOUTH CAROLINA.

Judging from the measurements of the eggs, all the cases I found in South Carolina were due to *Uncinaria americana*.

Date ? ? cases, ? deaths.

HEUSINGER and GEDDINGS, quoted by BLANCHARD, 1888a, could not be traced.

Adams Run, Colleton County, 1902 4 cases, 0 death.

STILES (1903b, p. 41): Orphans at Charleston.

Barnwell County, 1902	1 case, 0 death.
STILES (1903b, p. 41): Medical student at Charleston.	
Berkeley County, 1902	3 cases, 0 death.
STILES (1903b, p. 41): Orphans at Charleston.	
Camden, Kershaw County, 1902	2 cases, 0 death.
STILES (1903b, p. 39): Brickyard.	
Charleston, Charleston County, 1902	3 cases, 0 death.
DR. DE SAUSSURE, quoted by STILES (1903b, p. 41): Source of infection not stated.	
Charleston County, 1902	2 cases, 0 death.
STILES (1903b, p. 41): Medical students at Charleston; came from seacoast islands.	
Charleston, Charleston County, 1902	[15 cases, 0 death.]
STILES (1903b, p. 41): At orphan asylum. Children came from Dorchester (1), Berkeley (3), Colleton (4), and Charleston (7) counties	
Charleston, Charleston County, 1902	[4 cases, 0 death.]
STILES (1903b, p. 41): Medical students from Barnwell (1), Florence (1), and Charleston (2) counties.	
Florence, Florence County, 1902	1 case, 0 death.
STILES (1903b, p. 41): Medical student at Charleston.	
Lancaster and Kershaw counties, 1902	about 50 cases, 0 death.
STILES (1903b, pp. 40-41).	
McClellanville, Charleston County, 1902	4 cases, 0 death.
STILES (1903b, p. 41): Orphans at Charleston.	
Plum Island, Charleston County, 1902	3 cases, 0 death.
STILES (1903b, p. 41): Orphans at Charleston.	
Summerville, Dorchester County, 1902	1 case, 0 death.
STILES (1903b, p. 41): Orphan at Charleston.	

GEORGIA.

Judging from the size of the eggs, all the cases I found in Georgia were due to *Uncinaria americana*. Harris states that his cases were due to the same species.

Locality? Date?

LYELL quoted by BLANCHARD (1888a), could not be traced.

Richmond County, 1836

COTTING (1836a, pp. 288-290) states that clay is eaten by many people, especially by children. Probably at least some of the cases were connected with uncinariasis.

Pine Barrens of Georgia, 1845

LECONTE (1845, pp. 417-444) states that dirt-eating is common in the pine barrens of Georgia. His description refers quite clearly to uncinariasis, at least in part.

Appling County, 1902 1 case, 1 death.

HARRIS (1902a, pp. 99-100): Male, farmer, 29 years old. Healthy until 14 years of age, then observed that he was never so well in latter part of winter and spring as in summer and fall. Anemic; weak; food tastes salty; in spring the arms, hands, and dorsal surface of feet become greatly inflamed, blisters form, followed by scabs; severe constipation; pains in neck and stomach; vomiting frequent; weight 117 pounds; skin pale and wrinkled, smooth and dry; very little beard; mucous membranes very pale; tongue moist, shows indentations of teeth, and its epithelium in a large measure absent; teeth small, quite a number of them decayed; pulse 90, respiration 20, temperature 98° F.; body somewhat emaciated; heart with soft, blowing systolic murmur constant, varying greatly in intensity; marked venous hum over right jugular; just below the ensiform cartilage and to the left great tenderness; stomach normal in size and position; after Ewald trial meal, total acidity 64, HCl 40, combined HCl 4, phosphates 4; spleen and intestines normal; feces dark brick-red; *Uncinaria* eggs present; urine 2,300 cm. in twenty-four hours, light yellowish-red; specific gravity, 1.012, faintly alkaline, no sugar, at one time faint ring of albumin, albumose not present; urea in twenty-four hours, 21.15 grams, uric acid 0.475 gram, chlorids 3.15, phosphates 2.37, sulphates 2.82 grams. Blood: Red corpuscles 1,760,000, white 4,020, hemoglobin 20 per cent; decided though not extreme poikilocytosis, a number of microcytes; a few nucleated reds; small lymphocytes 28, large lymphocytes 14, transitional 6, polymorphonuclear leucocytes 50, eosinophiles 2. Vision, right eye 15-20, left eye 15-30. Diagnosis: Anchylostomiasis and possibly pellagra. Treatment: Afternoon, 10 grains of calomel; next day, 7 a.m., 30 grains of thymol in capsules; 9 a.m., 30 grains of thymol; 8 p.m., large dose of salts. Stools contained at least 420 worms.—HARRIS, 1902b, pp. 220-227. Same case.

Porter Springs 4 cases, 0 death.

Letter of H. F. HARRIS, dated August 9, 1902, to U. S. Bureau of Animal Industry. He states: "I am absolutely sure that this disease is very common in all this region." One of the four cases probably originated in Troup County, the other three in Lumpkin or neighboring county.

Locality ?, 1902 7 cases, 0 death.

HARRIS (1902c, p. 776) states that since reporting his first case he has discovered eleven new cases for Georgia. See also Porter Springs.

Atlanta, 1902 1 case, 1 death.

CLAUDE A. SMITH (1902, p. 1062): Case reported; mentioned also a similar case in a dog which had eaten some of the infected feces of the patient. Man died of pleuritic abscess. The specimens were collected post-mortem in a negro at Grady Hospital, Atlanta.

Dr. Smith kindly sent me the parasites for examination. The specimens from man (B. A. I., No. 3423) proved to be *Uncinaria americana*, while those from the dog (B. A. I., Nos. 3424 and 3425) were *Ancylostoma caninum*.

Atlanta, November, 1902 2 cases, 0 death.

CLAUDE A. SMITH informed me in a personal letter dated December 3, 1902, that he had just observed two cases, both from Florida. One was a man 50 years old, the other a dental student.

Albany, Dougherty County, 1902 about 5 cases, 0 death.

STILES (1903b, p. 43): People did not belong in Albany.

Americus, Sumter County, 1902 1 case, 0 death.

STILES (1903b, p. 41): Orphan in Macon.

- Baxley, Appling County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Buena Vista, Marion County, 1902** 2 cases, 0 death.
STILES (1903b, p. 41): Orphan in Macon.
- Cordele, Dooly County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Darien, McIntosh County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Effingham County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Fort Valley, Houston County, 1902** 50 cases, 0 death.
STILES (1903b, p. 42): Dr. BROWN stated he could easily find 50 or more cases. We examined about 10 cases together.
- Jackson County, 1902** ? cases, ? deaths.
Dr. HARDMAN, quoted by STILES (1903b, p. 41).
- Johnson County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Jones County, 1902** 4 cases, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Kinderloun Station, Lowndes County** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Lee County, 1902** 4 cases, 0 death.
STILES (1903b, p. 43): Observed with Dr. HILSMAN.
- Lyon, Tattnall County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Macon, Bibb County, 1902** [29 cases, 0 death.]
STILES (1903b, pp. 41-42): At orphan asylums. See Americus (1), Baxley (1), Buena Vista (1), Cordele (1), Darien (1), Effingham (1), Johnson (1), Jones (4), Kinderloun (1), Lyon (1), Monroe (1), Richwood (2), Sandersville (1), Thomasville (1), Savannah (1), Waycross (3), Monroe (1), Georgia. Also: Deland (4), Liveoak (1), Wacissa (1), Florida.
- Macon, Bibb County, 1902** about 25 to 30 cases, 0 death.
STILES (1903b, p. 42): About 25 to 30 cases; men, women, and children in the cotton-mill families.
- Monroe County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Richwood, Dooly County, 1902** 2 cases, 0 death.
STILES (1903b, p. 42): Orphan in Macon.
- Sandersville, Washington County, 1902** 1 case, 0 death.
STILES (1903b, p. 42): Orphan in Macon.

Savannah, Chatham County, 1902 1 case, 0 death.

STILES (1903b, p. 42): Orphan in Macon.

Thomasville, Thomas County, 1902 1 case, 0 death.

STILES (1903b, p. 41): Orphan in Macon.

Washington County, 1902 ? cases, 0 death.

In personal conversation with Dr. A. MOODY BURT, I was informed that there were a number of persons in Washington County who show in general the symptoms of uncinariasis.

Waycross, Ware County, 1902 3 cases, 0 death.

STILES (1903b, p. 42): Orphan in Macon.

Waycross, Ware County, 1902 ? cases, ? deaths.

STILES (1903b, p. 43): Many cases, number not estimated; about 20 cases of uncinariasis to 1 of malaria; on authority of Drs. IZLAR and WALKER.

Willacoochee and vicinity, Coffee County, 1902 200 cases, 0 death.

STILES (1903b, p. 43): Given on authority of Dr. WILCOX. We examined 8 cases together.

FLORIDA.

Judging from the size of the eggs all the cases I found in Florida, so far as examined microscopically, were due to *Uncinaria americana*.

Prior to 1845 ? cases, ? deaths.

LITTLE (1845) refers to dirt-eating; see STILES (1902b, p. 208).

Locality ?, 1902 ? cases, ? deaths.

GUITERAS'S cases; see STILES (1902b, p. 215).

Locality ?, 1902 1 case, 0 death.

HARRIS (1902c, p. 776): Locality not given; originated in Florida.

Baker County ? cases, ? deaths.

In personal conversation with a Jacksonville druggist, I was informed that so-called dirt-eaters are common in Baker County.

Clay County ? cases, ? deaths.

In personal conversation with a Jacksonville druggist, I was informed that so-called dirt-eaters are common in Clay County.

Deland, Volusia County, 1902 4 cases, 0 death.

STILES (1903b, p. 42): Orphans in Macon, Ga.

Jacksonville, Duval County, 1902 2 cases, 0 death.

STILES (1903b, p. 44).

Liveoak, Suwanee County, 1902 1 case, 0 death.

STILES (1903b, p. 42): Orphan in Macon, Ga.

Tampa, Hillsboro County, 1903 12 cases, 0 death.

In a letter dated March 21, 1903, Dr. J. S. HELMS says: "I have to date collected 12 cases and am yet working. I dare say that there are hundreds of cases in south Florida." The parasites were *Uncinaria americana*.

Wacissa, Jefferson County, 1902.....1 case, 0 death.

STILES (1903b, p. 42): Orphan in Macon, Ga.

Ocala, Marion County, 1902.....5 cases, 0 death.

STILES (1903b, p. 44).

Twiggs County, 1902.....? cases, ? deaths.

I have been informed that in Twiggs County there exists a condition which corresponds to uncinariasis.

Upson County.....? cases, ? deaths.

There is said to exist a great deal of "bloat" in this county. Possibly this "bloat" is due, in part at least, to uncinariasis.

Waldo, Alachua County, 1902.....about 12 cases, 0 death.

STILES (1903b, p. 44).

ALABAMA.

? Locality.....? cases, ? deaths.

LYELL, quoted by BLANCHARD, 1888a. Could not be traced.

Middle Alabama, 1902.....1 case, 0 death.

HARRIS (1902c, p. 776).

Mobile and vicinity.....24 cases, 0 death.

The following extracts are made from a letter dated March 3, 1903, from Dr. E. D. BONDURANT, professor of pathology, medical department, University of Alabama: "Some weeks ago a fellow practitioner told of cases of intense and protracted anemia he was treating, suggested the possibility of uncinariasis, and asked me to make a microscopic examination of the fecal discharges. This was done, and I had no difficulty in promptly identifying the hookworm ova in the feces of every one of his 4 cases. Shortly afterward I came upon 2 cases in my own practice, found the ova in quantity, and after thymol I found numbers of adult worms. At the city hospital we have already had several [?] others, and one physician who has actively taken up the search in his anemic country patients tells me that he has found about 15 cases. There is no doubt that the disease is *very common* in the country surrounding Mobile. * * * Our 'poor whites' are surely widely infected with the disorder * * *."

In a letter dated March 13, Dr. E. D. Bondurant says: "I have, since I last wrote you, diagnosed cases from Monroe County, Covington County, and Crenshaw County, this State, as well as numerous other cases in the district immediately around Mobile. * * * All of my cases have promptly improved after thymol."

Monroe County, 1903.....1 case, 0 death.

Quoted on the authority of a letter dated March 3, 1903, from Dr. E. D. BONDURANT.

Waldo, Talladega County.....? cases, ? deaths.

A trained nurse, Miss Edith Lide, has described to me a family at Waldo whose symptoms (anemia, heart, emaciation, dirt-eating, etc.) point almost unmistakably to hookworm disease.

MISSISSIPPI.

One of the American physicians (Dr. Kirby-Smith) who saw several cases of uncinariasis in Cuba has recently stated to me that this disease is undoubtedly present in Mississippi, but its exact nature has not been recognized. He is convinced that he himself has seen a number of cases which were confused with malaria.

ARKANSAS.

Uncinariasis does not appear to be proved as yet for Arkansas, but I have been told that it is probably present.

LOUISIANA.

Louisiana, prior to 1821 and 1850 ? cases, ? deaths.

CHABERT's (1821a) and DUNCAN's (1850, St. Mary Parish) accounts of dirt-eating apply very well to uncinariasis. See STILES (1902b, p. 207).

New Orleans, 1899 1 case, 0 death.

TEBAULT's (1899) case. See STILES (1902b, p. 209).

Dirt-eaters are said to be numerous in the Mississippi Delta near Baton Rouge.

TEXAS.

Locality?, 1864 1 case, 1 death.

HERFF's (1894) case in Mexican woman. See STILES (1902b, p. 208).

Galveston, 1893 1 case, 0 death.

ALLEN J. SMITH's case, reported by SCHAEFER (1901). See STILES (1902b, p. 208).

Galveston, 1900-1901 1 case, 0 death.

SCHAEFER's (1901) case; probably infected in Mexico. See STILES (1902b, p. 211).

Galveston, 1901 8 cases, 0 death.

ALLEN J. SMITH's cases, reported in part by SCHAEFER (1901). See STILES (1902b, p. 211). At least one of these cases was due to *Uncinaria americana*.

Encinal, La Salle County; Heampstead, Waller County; Lavaca County, 1898 ? cases, ? deaths.

Upon seeing my description of hookworm disease and the photograph from which figure 42 was made, MR. CHARLES A. PFENDER, assistant in the Zoological Laboratory, U. S. Bureau of Animal Industry, stated to me that he had seen similar conditions among Mexican children in Encinal, among negroes at Heampstead in Brazos River bottom, and among the poorer people in the southern portion of Lavaca County, along the Navidad River.

CENTRAL STATES.

ILLINOIS.

Chicago, 1902 1 case, 1 death.

CAPPS (1902a; 1903a, pp. 28-33): Patient, G. L., in Cook County Hospital; male; 52 years old; carpenter; American. Infection probably took place at Panama. Earliest symptoms two years ago, aching pain in upper belly, loss of appetite, and weakness. No nausea or vomiting. Bowels irregular, loose or constipated. Later, shortness of breath and dizziness; also palpitation of heart. In hospital fifteen months at New Orleans; diagnosis, pernicious anemia. September 9, 1902, admitted to Cook County Hospital; pains in belly, weakness, dyspnea, and palpitation. After sitting or standing feet would swell. Frequent dizziness and faintness. Occasionally had developed moderate fever, at which time epigastric pain was worse. Appetite poor. Constipation. Gradual, moderate emaciation.

"*Status presens*.—Man of medium build; skin of a lemon-yellow color. Fatty layer fairly well preserved. Sclerotics bluish and muddy. Lips and mucous membranes almost bloodless. Palpable arteries moderately thickened. Pulse of large volume, soft and compressible; low tension, with a decided water-hammer character. Lungs negative. Heart dullness extended to the left nipple line, to the upper border of the third rib above, and to the right edge of the sternum. The impulse was forcible and diffuse. Over the apex was a systolic blow transmitted to the anterior axil-

lary line. A louder bruit of a different pitch was audible over the mitral area and the base. The pulmonic sound was louder than the aortic closure.

"The spleen was not palpable, though its area of dullness was enlarged. The liver was not felt. The epigastric and umbilical regions were tender to pressure. Knee jerks present but not prompt.

"Temperature 98.6, pulse 90, respiration 20. Urine 1.015; no albumen, no sugar, and no casts.

"September 11, blood examination showed hemaglobin 18 per cent; reds, 2,576,000; whites, 6,600. No stained preparations were made.

"September 15, gastric contents were expressed one hour after a test meal of tea and toast. No free HCl present; no lactic acid.

"September 23, blood examination, hemog. 17 per cent; reds, 2,280,000; whites, 6,000.

"October 20, blood examination, hemog. 12.5 per cent; reds, 843,000; hematocrit, 980,000; whites, 4,500; color index, 0.80; volume index, 1.17. The differential count showed: small mononuclear, 10 per cent; large mononuclear, 11 per cent; polymorph. neutrophile, 66 per cent; polymorph. eosinophiles, 13 per cent; no rouleaux formation; no nucleated red cells; poikilocytosis marked; polychromatophilia marked.

"The presence of pronounced eosinophilia in a case of grave anemia made us strongly suspect the existence of an intestinal parasite, so that the stools were examined frequently. The earlier specimens of feces were watery from the rectal injections employed, and were therefore not easily studied. In a formed movement, however, the ova were found in large numbers. These eggs corresponded accurately in dimensions to those of *Uncinaria duodenalis*, measuring about 56 microns in length and 34 microns in width.

"Subsequently the eggs of *Tricocephalus dispar* were found in small number by Dr. J. L. Miller. Charcot-Leyden crystals were present in some preparations, absent in others. Cover glass smears of feces hardened in alcohol and ether were stained with hematoxylin and eosin and eosinophilic granulations demonstrated. These granulations, like the Charcot crystals, were never numerous, as is so often the case in ankylostomiasis.

"The eggs were successfully cultivated and the larvæ brought to mature development. These experiments will be described later.

"November 6, examination of the blood gave: hemaglobin 11 per cent; reds, 748,000; hematocrit, 915,000; whites, 5,600; color index, .88 per cent; volume index, 122 per cent. Differential count: small mononuclear, 15.8 per cent; large mononuclear, 6.8 per cent; polymorph. neutrophile, 70.2 per cent; eosinophile, 7.6 per cent; eosinophilic myelocytes, 0.2 per cent; mast cells, 0.4 per cent. Poikilocytosis and polychromatophilia marked. Coagulation time, five minutes.

"Previous to this examination the patient had taken thymol in small doses, and it is not unlikely that many parasites were swept away and lost in the stools. The diminished eosinophilia and the small number of eggs found in the stools thereafter lend support to this assumption.

"*History in the hospital.*—Treatment, on the whole, was unsatisfactory, because of the profound weakness of the patient and the irritable condition of the stomach. A persistent nausea set in that interfered with stomach feeding and made the administration of thymol ineffective and even hazardous. Nutrient and salt enemata were resorted to, but the vomiting persisted until the patient succumbed, on November 13.

"During his stay in the hospital the most conspicuous symptom was epigastric pain of a dull nature at first, subsequently colicky. In the last two weeks this pain became continuous, and was accompanied by a great tenderness over the epigastric and right hypochondriac regions. The liver mass extended at this time about 2 inches below the costal arch, and the tenderness, on pressure, was as great as that seen in hepatic abscess.

"The bowels, as a rule, were constipated, and required rectal enemata. The tem-

perature was usually normal, and ranged between 98.5° and 99.5° F. A tendency to hemorrhage was nowhere to be seen, except from the intestinal tract. The feces gave the prussian-blue reaction for iron.

"The examination of the eye grounds was twice carried out under difficulties. No retinal hemorrhage was apparent.

"The blood findings throughout were of a most suggestive nature; an anemia, at first of the secondary type, progressing until it corresponded in most respects to a primary pernicious anemia. The individual corpuscles grew larger and held an ever-increasing amount of hemoglobin, the color index rising from 38 to 88 per cent. and the volume index reaching 122 per cent. The poikilocytosis was sufficiently outspoken, as well as the polychromatophilia, for a primary anemia. The scarcity of nucleated red corpuscles and the entire absence of megaloblasts is unusual in the primary pernicious form, yet some such cases have been reported. What convinced us that the anemia was not of the usual primary type was the eosinophilia of 13 per cent, for in the primary disease the eosinophiles are rarely increased. On the other hand, the Uncinariæ and most of the other intestinal parasites are characterized by an increase in the eosinophilic cells.

"*Autopsy*.—The post-mortem examination was made November 13 by Dr. Harris, resident pathologist of the hospital. His report is as follows:

"Body is that of a fairly well-developed and fairly well-nourished man 162 cm. tall. Post-mortem rigidity and lividity present.

"There is a scar 0.5 cm. long on left arm, some edema of lower extremities. Panculus adiposus well preserved and of a light-yellow color.

"Abdominal cavity: Diaphragm reaches to the fifth rib on the right side and to the sixth rib on the left. Some free straw-colored fluid in peritoneal cavity. Omentum extends down to the pelvis over the intestines and contains a considerable quantity of fat.

"Pleural cavities: Some firm fibrous adhesions at right apex. About 1,000 c. c. straw-colored fluid in right pleural cavity; about 250 c. c. in left. Lungs do not meet in median line.

"Pericardial cavity: About 500 c. c. of straw-colored fluid in the pericardial cavity. This fluid contains a few fibrinous flocculi. The pericardium is thin and surface is smooth.

"Tongue, pharynx, larynx, not examined. Thymus absent. Esophagus and trachea negative.

"Lungs: Left lung smooth externally, marginal emphysema, crepitates throughout, floats in water, cut surface smooth, pale, and drips fluid. On the diaphragmatic surface is a caseated nodule 8 mm. in diameter. Right lung with the exception of the caseous nodule corresponds to the description of the left. Both lungs are quite free of pigment and weigh 2,870 grams. Peribronchial lymph glands are negative except for anthracosis.

"Heart: Cavities are quite empty, left ventricle contracted; aortic and pulmonary semilunar valves are competent, read by water test. Some fibrous thickening at the base of the aortic valves. One of the valves has small fenestration 3 mm. long. Pulmonary valves show no change. The mitral orifice admits three fingers, and the valve shows a small amount of fibrous thickening, especially near the free borders. The tricuspid orifice admits five fingers; the valves show no changes. The left ventricle has an aberrant corda tendina extending from the septum to the left wall. Ventricular wall measures 16 mm.; right ventricular wall measures 5 mm. Heart muscle is firm and very yellow, but not mottled. Heart weight, 300 grams. There is a slight increase of the subepicardial fat. There are a few atheromatous patches in the ascending aorta.

"Spleen: About one-half larger than normal; capsule is smooth, parenchyma is quite firm; malpighian bodies prominent; there is an evident increase of connective tissue. The organ weighs 225 grams.

"Kidneys: Right weighs 175 grams. Section pale, cortical markings not well seen; relation between cortex and medulla is normal; capsule strips readily; pelvis is normal. Left kidney weighs 135 grams. Answers to the description of its fellow.

"Ureters, bladder, testicles, and adrenals present no abnormal appearances.

"Liver: Extends 4 cm. below costal arch; capsule smooth and glistening—presents yellowish mottled appearance. Cut surface mottled yellow and red, lobules well seen. Liver cuts with decreased resistance. Weighs 1,600 grams. Bile ducts patent, bile dark brown, no concretions. Pancreas shows no changes.

"Stomach: Of normal size, externally is normal; mucosa is covered with much grayish-yellow mucus; no parasites.

"Small intestines: External appearance normal. Intestines contain a very large amount of very tenacious mucus. In the duodenum was found one hook worm. One hundred and fifty were found in the jejunum and upper part of ileum, being most numerous in the upper and middle jejunum. None found in last 18 inches of ileum. They were very adherent, and were in the proportion of about four females to one male. At point of attachment of some of the parasites was found a small ecchymotic spot, and scattered along the rest of the mucosa a few other ecchymotic spots were seen—possibly points of previous attachment. The mucus in places was blood-stained. Mesenteric glands were enlarged and of a pinkish color. Appendix lies in false pelvis to the outside of psoas muscle and behind cecum—bound down by fibrous adhesions and curled at its tip.

"Spinal cord shows no microscopic changes.

"Bone marrow removed from femur. Marrow is yellow and very fatty. At two points it had a reddish color, but was even here practically all fat.

"Anatomic diagnosis: 1. *Uncinaria duodenalis* of small intestine. 2. Ecchymosis of intestinal mucosa, and hemorrhage into intestinal lumen. 3. General anemia and edema of dependent portions of body. 4. Bilateral hydrothorax. 5. Hydropericardium. 6. Edema of lungs and caseous tuberculosis of lower left lobe. 7. Slight atheroma of aorta. 8. Fatty degeneration of heart and liver. 9. Aberrant corda tendina. 10. Passive congestion and fatty degeneration of liver. 11. Chronic interstitial splenitis."

WESTERN STATES.

MISSOURI.

St. Louis, 1893.....1 case, 0 death.

BLICKHAHN'S (1893a) case; probably imported from Germany and caused by *Ancylostoma duodenale*. See STILES (1902b, p. 208).

St. Louis, 1901.....1 case, 0 death.

DYER'S (1901) case. See STILES (1902b, p. 213).

CALIFORNIA.

San Francisco, 1902.....2 cases, 0 death.

Letters from Drs. G. H. EVANS and MARY HALTON, 1902: Two soldiers who returned from the Philippines. Through the kindness of the observers I was able to examine specimens from one of these cases, and to convince myself that they belonged to the American species. The previous history of the patient was not obtained.

San Francisco, 1903.....2 cases, 0 death.

BROWN (1903, p. 107): Three patients infected with *Strongyloides*; 2 of these (natives of Porto Rico) were also infected with *Uncinaria*.

? Locality.....3 cases, 0 death.

L. MIFFITT'S (cases cited by CAPPS, 1903a). Two cases from Mexico, one from the Philippines. Diagnosis by ova.

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For the general literature on uncinariasis the reader is referred to the Index-Catalogue of the Surgeon-General's Library, and also to the Index-Catalogue of Medical and Veterinary Zoology now being issued by the United States Bureau of Animal Industry. The following list, which has kindly been prepared for me from my manuscript by Mr. B. H. Ransom, comprises only those articles which are cited in the present paper. [W^a, Library, United States Department of Agriculture; W^m, Surgeon-General's Library, United States Army, Washington, D. C.]

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ADDENDA.

Since the first edition of this report was printed numerous new localities have been discovered for this disease. Two cases have been found by this laboratory in the Connecticut Hospital for the Insane, Middletown, Conn.; in North Carolina cases have been found in Morganton (Stiles), near Raleigh (Lewis and Stiles), and in Thomasville (Julian and Stiles); Dr. Corbett (see p. 39) has found new cases at Camden, S. C.; Dr. J. S. Helms, of Tampa, Fla., writes that outside the city limits he believes that about 90 per cent of the inhabitants are affected; he will soon report cases; Dr. Bondurant (see p. 106) and others have informed me that there are already more than 200 known cases around Mobile. With Dr. Harrison I found about five or six cases in Talladega; since then Dr. Harrison has found additional cases. Many other new localities are becoming known.

JULY 25, 1903.

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